TwiNSol-CECs

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2nd TwiNSol-CECs Workshop

Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting-Edge Technologies

Book of Abstracts

University of Novi Sad
Faculty of Technology Novi Sad
Novi Sad, Serbia

6 - 7 June 2024

BOOK OF ABSTRACTS

2nd TwiNSol-CECs Workshop

Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting-Edge Technologies

University of Novi Sad, Faculty of Technology Novi Sad (TFNS), Novi Sad, Serbia, June 6-7, 2024

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNOLOGY
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Dear colleagues, participants of the 2nd TwiNSol-CECs Workhop,

On behalf of the TwiNSol-CECs team, I am delighted to welcome you all to our 2nd Workshop with title "Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting-Edge Technologies" organized in the frame of TwiNSol-CECs project (GA 101059867). We deeply appreciate your contributions in the form of oral and poster presentations, with the abstracts and full papers compiled in the Book of Abstracts and Proceedings, available on our project website (www.twinsol-cecs.com). We are really proud in securing this project under Horizon Europe patronage and are honored by the opportunities such as this event, enabled through execution of TwiNSol-CECs, to share knowledge and exchange ideas within the environmental research with colleagues from Serbia, Western Balkans, and EU.

This event aims to bring together scientists and experts focused on, but not limited to, the issues on removal of contaminants of emerging concern (CECs) from water by innovative technologies. Since „Cutting-Edge Technologies" in water treatment are part of our focus in TwinSol-CECs project, the 2nd Workshop highlights three key innovative technologies: membrane processes, advanced oxidation, and biosorption. Each of these technologies offers unique and effective approach for removing micropollutants and contaminants of emerging concern (CECs) from water. These innovative technologies, each with its distinct advantages, represent significant advancements in our quest for clean and safe water. By integrating these methods, we can develop more comprehensive and effective strategies for managing water quality and protecting public health.

Beyond these topics, the Workshop also acts as a forum for exchanging research ideas, exploration of complementarities and possibilities for collaboration, contributing to the harmonization of research and innovation efforts crucial for the sustainable transition envisioned by the Horizon Europe and Green Deal calls towards a zero-pollution, toxic-free environment.

The TwiNSol-CECs team wishes you a pleasant stay in Novi Sad and looks forward to engaging discussions on new research ideas and collaborative efforts towards a zero-pollution future,

Prof. Zita Šereš
Chair

TwiNSol-CECs
GA101059867
TWINNING FOR EXCELLENCE IN ENVIRONMENTAL RESOURCES PROTECTION

2nd TwiNSol-CECs Workshop

Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting-Edge Technologies

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University of Novi Sad, Faculty of Technology Novi Sad,
Novi Sad, Serbia, 6-7 June 2024

PROGRAM

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNOLOGY
NOVI SAD

2nd TwiNSol-CECs Workshop

Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting-Edge Technologies

University of Novi Sad, Faculty of Technology Novi Sad, Serbia
June 6-7, 2024

Agenda

Thursday – 6 June 2024

Morning session, Faculty of Technology Novi Sad, Blue Hall
(Chairs: Vanessa J. Pereira and Zita Šereš)

9:00 – 10:00 Registration (Entrance Hall of TFNS)

10:00 – 10:15 Official opening, Biljana Pajin, Dean of the Faculty of Technology Novi Sad, and Zita Šereš, Chair of the Workshop

Plenary lectures (30 min per lecture + 5 min for Q&A after each lecture):

10:15 – 10:50 João G. Crespo, Sylwin Pawlowski, Svetlozar Velizarov – **Ion-Exchange Membrane Processes: Perspectives in Water Treatment and Desalination**

10:50 – 11:25 Olívia Salomé G. P. Soares – **Catalytic advanced oxidation processes for pollutants degradation**

11:25 – 11:55 *Coffee break*

Invited lectures (15 min per lecture + 5 min for Q&A after each lecture):

11:55 – 12:15 Sanja Panić, Mirjana Petronijević, Igor Antić, Jelena Živančev, Maja Buljovčić, Nataša Đurišić-Mladenović – **Heteroatom-doped pyrochar for efficient metal-free catalytic oxidation of contaminants of emerging concern**

12:15 – 12:35 Minja M. Bogunović, Ivana I. Ivančev-Tumbas – **Hybrid adsorption/membrane filtration in water treatment for the removal of organic micropollutants**

12:35 – 12:55 Nandor Nemestothy, Merve Visnyei, Veronika Kalauz-Simon, Peter Bakonyi – **Gaseous Byproducts in Wastewater Treatment: Challenges and Opportunities with Membrane Technology**

13:00 – 14:00 *Lunch*

14:00 – 14:30 *Poster session with Coffee*

Afternoon session, Faculty of Technology Blue Hall
(Chairs: Nandor Nemestothy and Nikola Maravić)

Invited lectures (15 min per lecture + 5 min for Q&A after each lecture):

14:30 – 14:50 Snežana Maletić, Jelena Beljin, Irina Jevrosimov, Tamara Apostolović, Srđan Rončević, Marijana Kragulj Isakovski – **The contribution of inoculated biochar to pesticide adsorption and biosorption**

14:50 – 15:10 Djurdja V. Kerkez, Milena R. Bečelić-Tomin, Anita S. Leovac Maćerak, Dragana D. Tomašević Pilipović, Dejan Krčmar, Nataša S. Slijepčević, Vesna Z. Pešić – **Sludge application on land: Opportunities and challenge**

Oral presentations (10 min per lecture + 5 min for Q&A after each lecture):

15:10 – 15:25 Szabolcs Kertész, Imre Vajk Fazekas, Martin Trancsik, Aws N. Al-Tayawi, József Richárd Lennert, Sándor Beszédes, József Csanádi, Tamás Szabó, Cecilia Hodúr, Gábor Veréb, Zsuzsanna László – **Enhancing the efficiency of low-pressure membrane separations using 3d printed spacers**

15:25 – 15:40 Aws N. Al-Tayawi, Hajnalka Csott, Nikolett Sz. Gulyás, József Richárd Lennert, Zsuzsanna Horváth Hovorka, Zsuzsanna László, Cecilia Hodúr, Szabolcs Kertész – **Evaluation of flow dynamics utilizing integrated 3d printed turbulence promoters for mitigation of membrane fouling**

15:40 – 15:55 Jelena Molnar Jazić, Tajana Simetić, Marijana Kragulj Isakovski, Aleksandra Tubić, Jasmina Agbaba – **Advanced oxidation processes for natural organic matter and emerging contaminats abatement in water treatment**

15:55 – 16:10 Jasmina Nikić, Malcolm A. Watson, Maja Vujić, Jovana Pešić, Jovana Jokić–Govedarica, Srđan Rončević, Jasmina Agbaba – **Addressing arsenic contamination: a polymer-based nanocomposite for water treatment**

Friday – 7 June 2024

Morning session, Faculty of Technology Blue Hall
(Chairs: João G. Crespo and Szabolcs Kertész)

9:00 – 10:00 Registration (Entrance Hall of TFNS)

Plenary lectures (30 min per lecture + 5 min for Q&A after each lecture):

10:00 – 10:30 Maria B. Cristóvão, Jorge Bernardo, Andreia Bento-Silva, Maria R. Bronze, João G. Crespo, Vanessa J. Pereira – **Mitigating Anticancer Drug Pollution: Nanofiltration for Control of Emerging Contaminants in Wastewater Effluents**

Invited lectures (15 min per lecture + 5 min for Q&A after each lecture):

10:30 – 10:50 Nikola Maravić, Zita Šereš, Jelena Šurlan, Nataša Đurišić-Mladenović, Igor Antić, Jelena Živančev, Carla Brazinha, Claudia F. Galinha, João G. Crespo – **Removal of acetaminophen and clarithromycin from water samples using nanofiltration and reverse osmosis**

10:50 – 11:10 Vesna M. Vasić, Dragana V. Lukić, Marina B. Šćiban – **Sewage sludge biochar as a sorbent for contaminants of emerging concerns removal from water**

11:10 – 11:30 Gábor Veréb, Laura Fekete, Tímea Miklós, Kata Fejes, Renáta Kovács, Ákos F. Fazekas, Erika Nascimben Santos, Szabolcs Kertész, Sándor Beszédes, Cecilia Hodúr, Zoltán Jákói, Gábor Kovács, Zsolt Pap, Tamás Gyulavári, Klára Hernádi, Zsuzsanna László – **TiO_2/CNT-modified pvdf composite membranes for enhanced membrane filtration of oily wastewaters**

11:30 – 12:00 *Coffee break*

12:00 – 12:20 Dragana, V. Lukić, Vesna, M. Vasić, Marina, B. Šćiban – **Multicomponent adsorption kinetics of micropollutants onto lignocellulosic biosorbents**

12:20 – 12:40 Nenad R. Grba – **Nano-geopolymer based remediation techniques for purification of different type of groundwater with high Mn, Fe and other metals/metalloids (As) content**

Oral presentations (10 min per lecture + 5 min for Q&A after each lecture):

12:40 – 12:55 Zoltán P. Jákói, Cecilia Hodúr, Sándor Beszédes – **Dielectric monitoring in wastewater-treatment and sludge utilization processes**

12:55 – 13:10 Maja Vujić, Vasiljević Sanja, Tajana Simetić, Jelena Molnar Jazić, Marijana Kragulj Isakovski, Jasmina Agbaba, Aleksandra Tubić – **Adsorption kinetitcs of organic pollutants on microplastic fibers in water**

13:10 – 14:10 *Lunch with coffee*

Afternoon session, Faculty of Technology Blue Hall
(Chairs: Olívia Salomé G. P. Soares and Nataša Đurišić-Mladenović)

Invited lectures (15 min per lecture + 5 min for Q&A after each lecture):

14:10 – 14:30 Ferenc E. Kiss – **Lessons learnt from life cycle assessment of advanced wastewater treatment processes**

14:30 – 14:50 Igor Antić, Jelena Živančev, Maja Buljovčić, Dušan Rakić, Nataša Đurišić-Mladenović – **Role of a high-resolution mass spectrometry in investigating processes for removal of contaminants of emerging concern from water**

Oral presentations (10 min per lecture + 5 min for Q&A after each lecture):

14:50 – 15:05 Marija Šobić, Mirjana Petronijević, Sanja Panić, Igor Antić, Jelena Živančev, Milan Tomić, Nataša Đurišić-Mladenović – **Removal of micropollutants from water using hydrochar obtained with process water recirculation**

15:05 – 15:20 Arijit Nath, Geremew Geidare Kailo, Abraham Amankwaa, Gabriella Kiskó, András Koris – **Production of Bioactive (Antioxidant and Antibacterial) Peptides from Soybean Milk Proteins by an Enzymatic Membrane Reactor**

15:20 – 15:40 Concluding remarks

Poster presentations, Central Lobby of TFNS (set-up: June 6, 11:25 – 11:55, dismantling: June 7, 13:10 – 15:40)

P1 APPLICATION OF PHYSICALLY ACTIVATED BIOCHAR FOR THE REMOVAL OF PHENOL FROM WATER
Aleksandra Adamović, Mirjana Petronijević, Saša Savić, Sanja Panić, Sanja Petrović, Nataša Đurišić-Mladenović

P2 POTENTIAL OF HYDROCHAR AS BIOSORBENT FOR HEAVY METAL IONS REMOVAL FROM WATER
Marco Barbanera, Alessandro Cardarelli, Vesna M. Vasić, Dragana V. Lukić

P3 INFLUENCE OF SELECTED CARRIER MATERIALS ON NATURAL COAGULANT PRODUCTION YIELD
Sanja Cojbasic, Maja Turk Sekulic, Jelena Prodanovic

P4 APPLICATION OF LEDs IN UV/CHLORINE AOPs FOR THE TREATMENT OF AQUEOUS SOLUTIONS OF POPs SUCH AS PHARMACEUTICALS
Anett Čović, Luca Farkas, Constance Csaplár, Teodóra Dragić, Tünde Alapi

P5 PREDICTION THE PHOTOCATALYTIC DEGRADATION RATE OF DICLOFENAC BY ARTIFICIAL NEURAL NETWORKS
S. Roy, L. Das Samanta

P6 ACTIVATION OF PEROXYMONOSULFATE WITH BIOCHAR - ADSORPTION AND ELIMINATION OF TRIMETHOPRIM ANTIBIOTIC FROM WATERS
Dinesh Chandola, Erik Sinkovics, Zsuzsanna László, Tünde Alapi

P7 COMBINED ION EXCHANGE AND MICROFILTRATION
Marijana Dragosavac

P8 LIGNIN DERIVED FROM CYNARA CARDUNCULUS AS AN EFFICIENT BIOSORBENT FOR CHROMIUM(VI) ION REMOVAL FROM WATER
Jorge Gominho, Ana Lourenço, Ricardo A. Costa, Duarte M. Neiva, Vesna M. Vasić, Dragana V. Lukić, Marina B. Šćiban

P9 JUTE FABRIC WASTE AS A PROMISING ADSORBENT FOR HEAVY METAL IONS AND ORGANIC DYES: A COMPREHENSIVE REVIEW
Aleksandra M. Ivanovska

P10 REMOVAL OF PHENOL FROM WATER BY USING FREE AND IMMOBILIZED HORSERADISH PEROXIDASE CATALYZED PROCESS
Milan P. Nikolić, Slobodanka Stanojević-Nikolić

P11 PRODUCTION OF ANTIOXIDANT AND ANTIBACTERIAL PEPTIDES FROM SOYBEAN MEAL BY AN ENZYMATIC MEMBRANE REACTOR
Arijit Nath, Geremew Geidare Kailo, Abraham Amankwaa, Gabriella Kiskó, András Koris

P12 APPLICATION OF LIGNOCELLULOSIC BIOSORBENT FOR SUGAR JUICE PURIFICATION IN FIXED-BED COLUMN
Lidija E. Perović, Jelena A. Miljanić, Julija Šupljika, Ivan Zdjelarević, Nikola R. Maravić, Zita I. Šereš

P13 REMOVAL OF CONTAMINANTS OF EMERGING CONCERN FROM WATER USING UV-H_2O_2 ADVANCED OXIDATION PROCESS
Mirjana Petronijević, Sanja Panić, Jelena Živančev, Igor Antić, Dušan Rakić, Nataša Đurišić-Mladenović

P14 Cu^{2+} ADSORPTION FROM AQUEOUS SOLUTION BY WASTE EGGSHELL POWDER
Sanja Petrović, Saša Savić, Mirjana Petronijević, Bratislav Todorović, Staniša Stojiljković

P15 PHENOL REMOVAL FROM WATER SOLUTION USING PEROXIDASE EXTRACTED FROM POTATO PEEL
Saša Savić, Sanja Petrović, Mirjana Petronijević

P16 THE MICROPLASTIC IS VISIBLE BY FLUORESCENCE UNDER STEREOMICROSCOPE
Živa Kolenc, Kaja Adamek, Sonja Smole Možina, Anja Klančnik

P17 THE ADVANTAGE OF LPM LAMPS EMITTING AT 185 NM - A SIMPLE SOLUTION TO ENHANCE THE EFFICIENCY OF PHOTOCHEMICAL WATER POST-TREATMENT PROCESS FOR ELIMINATING NON-BIODEGRADABLE ORGANIC POLLUTANTS
Tünde Alapi, Anett Čović, Luca Farkas, Réka Bíró, Gyöngyi Orosz

P18 INACTIVE BIOMASS OF THE FUNGUS *Ganoderma applanatum* AND ITS BIOSORPTIVE POTENTIAL FOR REMOVING MALACHITE GREEN FROM WASTEWATER
Natalija Velić, Marija Stjepanović, Jelena Vukoje, Janez Gorenšek, Sandra Budžaki, Marta Ostojčić

P19 EFFECT OF SODIUM CHLORIDE ON THE REMOVAL OF PHARMACEUTICALLY ACTIVE COMPOUNDS FROM WATER BY A REVERSE OSMOSIS MEMBRANE
Jelena Šurlan, Zita Šereš, Nikola Maravić, Nataša Đurišić Mladenović, Igor Antić, Jelena Živančev, Carla Brazinha, João G. Crespo

P20 PRELIMINARY PRODUCTION COST ESTIMATION FOR BIOSORBENTS DERIVED FROM PEACH STONES
Danijela Z. Stefanović, Marija R. Miladinović, Biljana S. Đorđević, Milan D. Kostić, Olivera S. Stamenković

P21 ADSORPTION EFFICIENCIES OF INDIAN NEEM LEAVES FOR REMOVAL OF CONGO-RED DYE FROM AQUEOUS SOLUTION FOR SUSTAINABLE ENVIRONMENT
Radharani Das, Ishita Sinha, Soumyajit Maity, Subhojit Ash

P22 ADSORPTIVE REMOVAL OF Cr (VI) FROM SYNTHETIC WASTES USING AGRICULTURAL WASTES: A GREEN APPROACH
Radharani Das, G. Roymahapatra, Ishita Sinha, Soumyajit Maity, Subhojit Ash

PLENARY LECTURES

Prof. João G. Crespo, Dean of ITQB NOVA (circa 500 collaborators, researchers and PhD students). Professor of Chemical Engineering at the School of Science and Technology – NOVA University of Lisbon (NOVA FCT). Director of the Laboratory of Membrane Processes at iBET. Former Vice-Rector for Research and Innovation and former Coordinator of NOVA Doctoral School. Member of the Portuguese Academy of Engineering. Honorary member of the European Membrane Society. Supervisor/co-supervisor of more than 50 PhD students (concluded). Editor of 2 books; Author/co-author of 23 book chapters and 390 publications referred in Scopus, and of 5 families of patents. Co-founder of the spin-off company "Zeyton Nutraceuticals". Research Keywords: Membrane materials and processes; Water treatment and valorization of bioresources; Process Monitoring. **Lecture on: Ion-Exchange Membrane Processes: Perspectives in Water Treatment and Desalination**

Prof. Olívia Salomé Gonçalves Pinto Soares, Assistant Researcher at the Faculty of Engineering of the University of Porto, ALiCE - Associate Laboratory in Chemical Engineering and LSRE-LCM Laboratory of Separation and Reaction Engineering - Laboratory of Catalysis and Materials, Portugal. Salomé Soares has a background in the field of Chemical and Environmental Engineering, focused on heterogeneous catalysis, having relevant experience in the design of nanostructured materials, metal-free, supported metal or metal oxide catalysts, as well as in their application in environmental technologies (water/wastewater treatments, abatement of air pollutants), CO2 valorisation, electrochemical energy conversion, and smart textiles. She co-authored more than 160 publications in ISI-indexed papers (H-index 36) and more than 200 communications in conference proceedings and co-inventor of 4 patent applications. **Lecture on: Catalytic advanced oxidation processes for pollutants degradation**

Vanessa Pereira is Assistant Researcher at iBET in Portugal. She holds a Master's and a PhD in Environmental Engineering from the University of North Carolina at Chapel Hill, USA. She has experience in the analysis of emerging pollutants in drinking water and wastewater, as well as in water treatment, with an emphasis on direct photolysis, advanced oxidation processes, membrane processes, and the combination of these treatments (in sequence or hybrid reactors) to produce high-quality drinking water or wastewater effluents that can be reused for various applications. She has supervised/co-supervised 38 students, participated in and coordinated several national and international research projects with multidisciplinary and multicultural teams. She is the author of 54 scientific publications in peer-reviewed journals as well as 135 poster and oral presentations at national and international conferences. Her dedication to scientific dissemination also includes active participation in educational activities for children in schools in Portugal and the USA, as well as events promoted by ITQB and iBET for the general public. **Lecture on: Mitigating Anticancer Drug Pollution: Nanofiltration for Control of Emerging Contaminants in Wastewater Effluents**

ION-EXCHANGE MEMBRANE PROCESSES: PERSPECTIVES IN WATER TREATMENT AND DESALINATION

***João G. Crespo*[1,2*], Sylwin Pawlowski[1], Svetlozar Velizarov[1]**
[1] *LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal*
**jgc@fct.unl.pt*
[2] *Instituto de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Av. da República, 2780-157 Oeiras, Portugal*

In this lecture, the original concept of ion-exchange membrane (bio)reactor and its design and use for the removal of ionic inorganic pollutants from drinking water supplies will be presented and discussed. The target pollutants include nitrate, nitrite, perchlorate, arsenate and ionic mercury. The mechanism of ionic transport will be discussed as well as the methodology for process optimization.
Additionally, the concept of capacitive deionization will be presented as well as the recently proposed flow capacitive deionization (FCDI) using flow electrodes. Different applications will be discussed, including the recovery of lithium from brines. The impact of fluid rheology on the design of the FCDI cell will be emphasized.
Perspectives and research needs for the implementation of ion-exchange membrane processes in water treatment and desalination will be discussed.

Keywords: Ion-exchange, Water treatment, Water desalination, Donnan Dialysis, Capacitive deionization

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CATALYTIC ADVANCED OXIDATION PROCESSES FOR POLLUTANTS DEGRADATION

Olívia Salomé G. P. Soares[1,2]
[1]*LSRE-LCM - Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal.*
[2] *ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*
salome.soares@fe.up.pt

Water is a natural and indispensable resource for life on earth, being necessary to safeguard its quality and reduce contamination levels. Advanced oxidation processes (AOPs) have emerged as promising technologies for removing a wide range of pollutants present in water. These treatments are characterized by the formation of highly reactive species, such as hydroxyl radicals, which can rapidly and indiscriminately promote the degradation of several organic compounds in solution. Nevertheless, these processes present limitations in removing some pollutants, and complete mineralization is only achieved after several hours or is never reached. The combination of AOPs with heterogeneous catalysts is being applied to overcome these drawbacks, exhibiting significant advantages. Recent studies demonstrated that carbon materials' textural and chemical properties could be tailored for environmental applications by adequate preparation methods enhancing their performances. In particular, the design of novel catalysts engineered from the nano-scale up has been shown to improve mineralization degrees towards the required levels for practical applications. The present work will describe the degradation of emerging water pollutants by several AOPs, such as ozonation, photolysis, hydrogen peroxide oxidation, wet air oxidation and combinations of these processes in which the addition of different novel catalysts was also considered.

Keywords: Advanced oxidation processes, Heterogeneous catalysis, Carbon materials

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MITIGATING ANTICANCER DRUG POLLUTION: NANOFILTRATION FOR CONTROL OF EMERGING CONTAMINANTS IN WASTEWATER EFFLUENTS

Maria B. Cristóvão[1,2], Jorge Bernardo[2], Andreia Bento-Silva[3], Maria R. Bronze[1,3], João G. Crespo[2], Vanessa J. Pereira [1,4*]

*[1] iBET, Instituto de Biologia Experimental e Tecnológica, Apartado 12, 2781-901 Oeiras, Portugal, *vanessap@ibet.pt*

[2] LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal

[3] Faculdade de Farmácia, Universidade de Lisboa, 1649-003 Lisboa, Portugal

[4] Instituto de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Av. da República, 2780-157 Oeiras, Portugal

Anticancer drugs have been increasingly reported to occur in various water sources, including hospital and wastewater effluents, raising concerns about their environmental impact. With the rising number of cancer cases, the consumption of these drugs is expected to increase, emphasizing the urgency for effective treatment methods to prevent their discharge into aquatic environment. This study aimed to propose a solution to mitigate the release of anticancer drugs into the environment.

An analytical method combining solid phase extraction and liquid chromatography with tandem mass spectrometry was optimized to detect these emerging contaminants in wastewater effluents. An occurrence study was conducted using grab samples and passive samplers to assess temporal variations in the drug concentrations.

Laboratory-scale experiments were then performed to evaluate the efficacy of different nanofiltration membranes for treating these compounds spiked in laboratory-grade water, synthetic urine, and a real secondary effluent. High percent rejections were obtained with the Desal 5DK nanofiltration membrane. A pilot-scale nanofiltration unit was then implemented in a wastewater treatment facility to validate laboratory findings and optimize operational parameters that guarantee a high drug rejection while minimizing fouling.

The diverse structures and properties of the tested anticancer compounds suggest a broad applicability of nanofiltration for pollutant removal. Implementation of nanofiltration in wastewater treatment plants is therefore considered promising to safeguard the aquatic environment.

Keywords: Anticancer drugs, Wastewater effluents, Occurrence, Nanofiltration, Pilot scale

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INVITED LECTURES

HETEROATOM-DOPED PYROCHAR FOR EFFICIENT METAL-FREE CATALYTIC OXIDATION OF CONTAMINANTS OF EMERGING CONCERN

Sanja Panić, Mirjana Petronijević, Igor Antić, Jelena Živančev, Maja Buljovčić, Nataša Đurišić-Mladenović***
University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia,
**sanjar@tf.uns.ac.rs*

The widespread occurrence of contaminants of emerging concern (CECs) has been a very important issue in the field of environmental remediation, giving rise to concerns about their potential toxic effects to aquatic ecosystems and human beings. Many of these compounds are not the subject of routine monitoring or emission control, and current efforts to prevent and mitigate their risks are insufficient. Due to a trace concentration and often recalcitrant nature of CECs detected in wastewater, conventional water treatment technologies are not efficient in their elimination. Persulfate-based advanced oxidation processes have been recently recognized as effective strategy for the removal of emerging pollutants. Compared to other remediation technologies, these processes offer several benefits including being eco-friendly, cost effective and possibility of achieving total mineralization of contaminants. Persulfate activation using heterogeneous catalysts is simpler, more efficient and economical compared to energy-based activation methods. Therefore, the design of engineered catalyst with adjustable physicochemical properties and superior performance for the removal of CECs remains an important challenge.

In this study, novel metal-free carbocatalysts were prepared *via* simple green synthetic route (ball-milling and subsequent pyrolysis at 600°C) using pinewood sawdust, as carbon precursor, and cheap precursors of urea and boric acid as nitrogen and boron sources, respectively. The obtained single-doped (N-, B-doped), as well as the N/B co-doped pyrochar were employed as metal-free activators of peroxydisulfate (PDS) for the degradation of 22 CECs in a water solution model mixture (10 µg/l concentration of each compound) – 11 pesticides and 11 pharmaceutically active compounds. The roles of dopants, intrinsic and extrinsic properties of the synthesized catalysts were systematically investigated and correlated with their performance in persulfate oxidation of selected CECs. Additionally, the degradation kinetics of each individual pollutant has been explored. The results demonstrated that all the prepared carbocatalysts manifested excellent activity for 20 tested CECs, being superior activators for the degradation of pharmaceutically active compounds compared to the tested pesticides. The B-doped pyrochar exhibited great capability to boost persulfate activation for ~100% removal of 7 pesticides and all pharmaceutically active compounds. It is expected that this study provides new insights into the rational design of cost-effective, eco-friendly and highly efficient metal-free carbocatalysts as promising candidates for practical applications of CECs removal from wastewater.

Keywords: Persulfate-based oxidation, Pyrochar, Metal-free carbocatalysts, CECs

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HYBRID ADSORPTION/MEMBRANE FILTRATION IN WATER TREATMENT FOR THE REMOVAL OF ORGANIC MICROPOLLUTANTS

Minja M. Bogunović and Ivana I. Ivančev-Tumbas*

University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia;

**minja.bogunovic@dh.uns.ac.rs*

The presence of organic micropollutants (OMPs) in water bodies is a growing environmental problem since some of them can easily pass through water treatment barriers. One of the ways to remove them from water is use of hybrid membrane processes that combine adsorption and coagulation with membrane filtration. In addition to removal of microorganisms by microfiltration or ultrafiltration, such a process simultaneously removes OMPs by adsorption on powdered activated carbon (PAC) and bulk organic matter by coagulation (CoA). In our investigations we used lab-scale pilot plant (30L/h) that combines ultrafiltration with the possibility of inline dosing of PAC and CoA for the removal of OMPs from both surface water (river and reservoir) and wastewater. Experiments showed different removal efficiencies, depending on the water matrix, sorbent dose, coagulant applied and OMPs tested (4-99%). Presentation will show comprehensive overview of the results obtained in different conditions, including testing not only PAC, but also eco-sorbents designed and produced in laboratories of the University Duisburg Essen from Germany.

Keywords: Organic micropollutants, Hybrid membrane process, Adsorption, Coagulation

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GASEOUS BYPRODUCTS IN WASTEWATER TREATMENT: CHALLENGES AND OPPORTUNITIES WITH MEMBRANE TECHNOLOGY

Nandor Nemestothy**, Merve Visnyei, Veronika Kalauz-Simon, Peter Bakonyi
University of Pannonia Research Group on Bioengineering, Membrane Technology and Energetics 8200 Veszprem Hungary
**nemestothy.nandor@mk.uni-pannon.hu*

Wastewater treatment processes generate various gaseous substances. While some, like nitrogen released during denitrification, play a role in the treatment itself, others require specific management due to their hazard or potential value. Methane (CH_4), for instance, poses environmental concerns as a potent greenhouse gas but holds promise as a renewable energy source if captured and enriched. Hydrogen (H_2) and hydrogen sulfide (H_2S) are further examples of gases with both risks and potential benefits.
This presentation explores membrane engineering solutions for addressing these gaseous byproducts in wastewater treatment. We will discuss the application of both porous and dense membranes for gas separation and enrichment. Two case studies will be presented:

1. Biohydrogen recovery and enrichment using a membrane bioreactor equipped with a Polydimethylsiloxane (PDMS) membrane.
2. Methane recovery utilizing a membrane contactor technology.

These case studies showcase the potential of membrane engineering for transforming wastewater treatment into a more sustainable process by capturing valuable gaseous resources while mitigating environmental impact.

Keywords: Membrane technology, Gas separation, Membrane contactor, Biohydrogen, Biomethan

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THE CONTRIBUTION OF INOCULATED BIOCHAR TO PESTICIDE ADSORPTION AND BIOSORPTION

Snežana Maletić, Jelena Beljin, Irina Jevrosimov, Tamara Apostolović, Srđan Rončević, Marijana Kragulj Isakovski***

University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21000 Novi Sad, Republic of Serbia

**snezana.maletic@dh.uns.ac.rs*

Environmental pollution poses significant threats to human health and ecosystems, highlighting the need for effective remediation strategies. Traditional methods of remediation are often costly and time-consuming, driving the search for new, more efficient materials. Carbon-based materials have emerged as promising candidates due to their eco-friendly properties and expanding use in pollution control.

This study investigated sorption experiments in stainless-steel columns (4 cm diameter, 20 cm length) filled with soil amended with biochar pre-inoculated with a biofilm of vegetative cells from Bacillus megaterium BD5. To assess the impact of inoculated biochar on pesticide sorption, 0.5% of this adsorbent was added to the total soil mass in the column. Thiourea was used as a tracer at a concentration of around 4 mg/L. Pesticide solutions were then passed through the column, and eluates from the outlet were collected at various intervals and analyzed for pesticide concentrations using GC/MS Agilent 7890 A/5975C.

Analysis involved using a mathematical transport model to solve the advection-dispersion equation (ADE), which provided transport parameters such as retardation (R_d) and biodegradation (λ), as well as breakthrough curves. The retardation coefficient for the compounds investigated ranged from R_d=40-100, with Parathion-methyl < Fenthion < Fenitrothion showing an increasing order of retardation. Biodegradation (λ) of the compounds ranged from λ=0.2-3.3, also increasing in the same order. Interestingly, there was no clear correlation observed between the octanol-water partition coefficient, retardation, and biodegradation, suggesting that hydrophobicity alone did not determine sorption and transport characteristics in these specific conditions. In summary, the introduction of inoculated biochar is likely to enhance the simultaneous adsorption of organic compounds onto the added adsorbents within the porous material and biosorption onto the inoculated biochar. The addition of inoculated carbon-based materials to contaminated sediments demonstrates potential as a remediation technique, effectively inhibiting pollutant leaching to groundwater and facilitating immobilization. This approach holds promise for improving the overall effectiveness of remediation efforts in contaminated environments.

Keywords: Sorption, Remediation, Pesticides, Soil, Groundwater

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SLUDGE APPLICATION ON LAND: OPPORTUNITIES AND CHALLENGES

Djurdja V. Kerkez*, Milena R. Bečelić–Tomin, Anita S. Leovac Maćerak, Dragana D. Tomašević Pilipović, Dejan Krčmar, Nataša S. Slijepčević, Vesna Z. Pešić
University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovica 3, 21000 Novi Sad, Republic of Serbia
**djurdja.kerkez@dh.uns.ac.rs*

The concept of a circular economy implies a new approach to traditional wastewater treatment plants that is promoted to address important sustainability segments such as emissions, chemical consumption, water and energy interdependence and increasing amounts of post-treatment residues or bio-solids. Sludge is an organic substrate relatively rich in nutrients (nitrogen and phosphorus), as well as trace elements. The composition of sludge varies regionally and seasonally, but in general there is little monitoring of data on the content of nutrients in it. It is estimated that about 2.3-3.1 Mt of nitrogen and about 0.23 Mt of phosphorus are found in the sludge generated during one year in the world. Sludge produced from treatment of domestic sewage has long been applied to agriculture as a source of nutrients to displace mineral fertilizers.

In this research, excessive literature review was performed to access the sludge management practices in Europe. In addition, nutrient potential in sludge was evaluated on a national level. Major opportunities and challenges were identified.

27% of produced sludge in Europe is used in agriculture as fertilizer on arable land and pastures. This method is dominant in Bulgaria, Croatia, the Czech Republic, Denmark, Ireland, Lithuania, Norway, Spain and Sweden. Composting and similar uses: use of waste sludge after mixing with other organic material and composting, followed by use for parks and gardens takes about 21%. This method is dominant in Cyprus, Estonia, France, Hungary, Luxembourg and Slovakia. According to national sludge management program, in Republic of Serbia around 135 000 tons of dry mater of sludge can be expected in the future. This represents the source of nitrogen and phosphorus in amount of over 4500 tons each.

On the other hand, concerns arise from the possibility of the presence of various emerging contaminants. However, these risks should be viewed rationally in relation to the characteristics of the wastewater entering the plant, as well as through the efficiency and type of applied technologies in the water line, which is closely related to the quality of the separated sludge. By controlling the users of the sewage system and optimizing the operation of the wastewater treatment plant, these risks can be reduced to a minimum. Furthermore, more efficient technologies to preserve extract and reuse nutrients from sewage sludge can be used.

Finally, states need to recognize the real value of wastewater and the potential resources that can be recovered from it. They must include resource recovery and general circular economy principles in their strategies, investment planning and infrastructure design.

Keywords: Sludge management, Biosolids, Nutrients, Resource recovery, Circular economy

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REMOVAL OF ACETAMINOPHEN AND CLARITHROMYCIN FROM WATER SAMPLES USING NANOFILTRATION AND REVERSE OSMOSIS

Nikola Maravić*[1*], Zita Šereš[1], Jelena Šurlan[1], Nataša Đurišić-Mladenović[1], Igor Antić[1], Jelena Živančev[1], Carla Brazinha[2], Claudia F. Galinha[2], João G. Crespo[2,3]

[1]University of Novi Sad, Faculty of Technology, Bul. cara Lazara 1, 21000 Novi Sad, Serbia
**maravic@uns.ac.rs*
[2] LAQV-REQUIMTE, DQ, FCT NOVA, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
[3] ITQB, Universidade NOVA de Lisboa, Av. da República, 2780-157 Oeiras, Portugal

Acetaminophen and clarithromycin are both contaminants of emerging concern in water systems due to their widespread use and incomplete removal by conventional wastewater treatment processes. Pharmaceuticals such as acetaminophen and clarithromycin can easily enter surface water systems through the disposal of unused medications or via excretion. Polyamide membranes for both reverse osmosis, SW30HR (Filmtec, USA), and nanofiltration, NF270 (Filmtec, USA), were used for investigating removal of corresponding two pharmaceutics. All experiments were conducted in METCell® dead-end unit (EVONIK, Germany). This study investigated the impact of pH on the rejection rates of acetaminophen and clarithromycin by SW30HR and NF270 membranes. The results showed that at pH 4, both membranes exhibit higher rejection rates for clarithromycin compared to acetaminophen. However, at pH 10, NF270 membrane showed significantly higher rejection rates for acetaminophen compared to the experiments conducted at pH 4 and pH 7. On the contrary, clarithromycin showed different trend with the rising pH value in NF270 experiments. SW30HR membrane rejection rates of all tested pharmaceutics are higher in all experiments confirming hypothesis of dominating size exclusion mechanism in the investigated reverse osmosis process. These findings highlight the pH-dependent behavior of the membranes in rejecting pharmaceutical compounds, which could be crucial in designing efficient membrane processes for pharmaceutical wastewater treatment.

Keywords: Acetaminophen, Clarithromycin, Reverse osmosis, Nanofiltration, Polyamide.

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SEWAGE SLUDGE BIOCHAR AS A SORBENT FOR CONTAMINANTS OF EMERGING CONCERNS REMOVAL FROM WATER

Vesna M. Vasić**, Dragana V. Lukić, Marina B. Šćiban
University of Novi Sad, Faculty of Technology Novi Sad, Bul. cara Lazara 1, 21000 Novi Sad, Serbia,
**vesna.vasic@uns.ac.rs*

The continuous release of contaminants of emerging concerns (CECs) into the environment has been recognized as a danger to the ecosystem and human health. Through sewage, these compounds reach the wastewater treatment plants, which are ineffective in the CECs removal, so they remain in the effluent and are discharged into the water bodies. Thus, it is necessary to evaluate and develop effective technologies for the remediation of CECs.
Biosorption is one of the most promising low-cost techniques for water treatment. In recent years, various materials have been tested as biosorbents, and more recently, attention has been drawn to sewage sludge as a raw material for biochar production, which may be promising from the viewpoint of circular economy and waste management. In recent years, the quantity of sewage sludge has been increasing globally, due to the increased number of wastewater treatment plants, so the need to manage this waste has become an important issue. This paper will summarize the state of the art on the application of sewage sludge biochar as an adsorbent for CECs removal from water. It is obvious from the literature that specific properties and porose structure make it suitable for the removal of contaminants from water.

Keywords: Sewage sludge, CECs, Biochar, Wastewater treatment.

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TiO_2/CNT-MODIFIED PVDF COMPOSITE MEMBRANES FOR ENHANCED MEMBRANE FILTRATION OF OILY WASTEWATERS

***Gábor Veréb*[1*], Laura Fekete[1], Tímea Miklós[1], Kata Fejes[1], Renáta Kovács[1], Ákos F. Fazekas[1], Erika Nascimben Santos[1], Szabolcs Kertész[1], Sándor Beszédes[1], Cecilia Hodúr[1], Zoltán Jákói[1], Gábor Kovács[2], Zsolt Pap[3], Tamás Gyulavári[3], Klára Hernádi[4], Zsuzsanna László[1]**

[1]*Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Moszkvai Blvd. 9, HU-6725 Szeged, Hungary, *verebg@mk.u-szeged.hu*

[2]*Department of Horticulture, Faculty of Technical and Human Sciences, Sapientia Hungarian University of Transylvania, 400112 Cluj-Napoca, Romania*

[3]*Department of Applied and Environmental Chemistry, Institute of Chemistry, University of Szeged, Rerrich Béla sqr. 1, H-6720 Szeged, Hungary*

[4]*Institute of Physical Metallurgy, Metal Forming and Nanotechnology, University of Miskolc, Miskolc-Egyetemváros, C/1 108, HU-3515 Miskolc, Hungary*

Oily wastewaters are produced all over the world by several activities. The most conventional techniques (skimming, flotation, sand filtration, etc.) must be augmented with advanced methods for the efficient elimination of micro- and nanoscale oil droplets. As water quality regulations tighten, membrane filtration has become more popular for wastewater treatment, since the technology is known for its simplicity in operation, non-chemical properties, and exceptional cleaning efficiency. However, it is necessary to develop membranes to minimize the impact of fouling when oily wastewaters are membrane filtered.

In the present study, PVDF membranes were modified with different TiO_2/CNT nanocomposites, and the membranes were used to filter crude oil emulsions (c=100 mg/L; V = 250 mL) with a dead-end type membrane reactor (Millipore XFUF07601) at different transmembrane pressures (0.1-0.3 MPa) up to a volume reduction ratio (VRR) of 5. The main filtration parameters (such as fluxes, filtration resistances, flux recovery ratios, purification efficiencies) were compared at varying conditions (e.g. altering transmembrane pressures, pH value, oil sample) in the case of the pure PVDF and the TiO_2/CNT-modified PVDF composite membranes. The nanocomposite-based modification proved to be efficient to enhance the fluxes and flux recovery ratios and proved to be efficient to increase the purification efficiency in most of the examined cases.

Keywords: Membrane filtration, Oil emulsion, TiO_2, CNT, Composite membrane

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MULTICOMPONENT ADSORPTION KINETICS OF MICROPOLLUTANTS ONTO LIGNOCELLULOSIC BIOSORBENTS

Dragana, V. Lukić*, Vesna, M. Vasić, Marina, B. Šćiban
University of Novi Sad, Faculty of Technology Novi Sad, Bul. cara Lazara 1, 21 000 Novi Sad, Serbia,
**dkukic@uns.ac.rs*

Over the past few decades, the presence of chemicals of emerging concern (CECs) presence in water bodies has raised concerns due to potentially harmful effects on human health and the environment. One of their primary pathways to water bodies is wastewater treatment plants since conventional treatment is inefficient in the removal of CECs. The removal of micropollutants represents a major challenge due to their low concentrations, complex mixtures, and diverse sources of contamination. Innovative wastewater treatment technologies for the efficient removal of CECs include advanced oxidation processes, membrane filtration, and activated carbon adsorption. Each of these technologies has its advantages and limitations, and ongoing research seeks to optimize their performance, cost-effectiveness, and scalability for widespread implementation.
Due to the high cost of the adsorption process, the focus of active research in this area is the development of effective and novel materials for pollutant removal. There are two main directions in searching for these materials: the usage of natural, abundant, mainly waste materials (row or modified) and the development of new synthetic materials.
In this paper, raspberry cane and lignin isolated from this waste material were investigated as potential biosorbents for the removal of chemicals of emerging concern from a synthetic mixture. The multi-component adsorption kinetics of 35 different compounds was carried out in a batch mode. 0.5 g of each adsorbent was mixed with 500 ml of a mixture of CECs (neutral pH) for 24 hours. At different time intervals, an aliquot of the mixture was taken and residual concentrations of CECs were determined. The results revealed that the same 14 compounds showed no adsorption on both of the investigated biosorbents. The rest of the CECs appeared to be adsorbed fast, mostly during the first 60 min of the process. For all compounds, the equilibrium was reached within 6 hours. For 11 compounds removal was over 80% either by raspberry cane or lignin. However, lignin appeared to be generally slightly more efficient and it adsorbed more different components than raspberry cane.

Keywords: Micropollutants, Wastewater treatment, Biosorption, Raspberry cane, Lignin.

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NANO-GEOPOLYMER BASED REMEDIATION TECHNIQUES FOR PURIFICATION OF DIFFERENT TYPE OF GROUNDWATER WITH HIGH Mn, Fe AND OTHER METALS/METALLOIDS (As) CONTENT

Nenad R. Grba
University of Novi Sad, Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, Trg Dositeja Obradovica 3, 21000 Novi Sad, Serbia ,
nenad.grba@dh.uns.ac.rs

The main objective of this research was to develop and implement innovated sustainable and cost-effective water remediation technologies at laboratory (TRL 4) to Pylot scale (TRL 8), based on novel and tailored nano-geopolymers without irradiation of biota. Therefore for the first time, contaminated groundwater is remediated at high manganese concentration (from 50 to 300 µg/l) and potentially other metal ions removal efficiency by coupling a newly developed groundwater purification process and a flow-through column system loaded with green, low-cost geopolymers (based on natural Ecuadorian (NatAllo) allophane). The removal efficiency, binding capacity and leachability of heavy metals from groundwater was assessed by state-of-the-art mineralogical, thermo-analytical and spectroscopic methods and mass spectrometry, in line with local and EU guidelines. In groundwater from Novi Sad (NS), Republic of Serbia (with Mn content ca. 120 µg/l)) and also Laktaši, Bosnia and Herzegovina Mn level that was not showed effects after aeration process (similar as inlet water (ca. 300 µg/l) the contents of Mn was achieved below the maximum allowable concentrations (MACs) (<50 µg/l) by Official Gazette of SR (42/98 and 44/03) and EU Directive 1998/83/EC. The daily and multi-day experiment showed that level below MACs values were achiwed. Simillar to batch preliminary results, this was great scientifical and applicable breakthrough and aditional anlysis were done.
The testing on state of the art instrumental techniques were done by Graz University of Technology, Institute of Applied Geosciences, Graz, Austria: Electron energy-loss spectroscopy (EELS), Transmission electron microscopy (TEM) and FFT / SAED, PHREEQ-C for hydrochemical modeling. These tests show the novel attitude towards data from these geopolymer analyses and give the valuable information for fitting of batch and column inlet and outlet data due to dominantly Mn but also Fe and other metals parameters regarding long - term water purification efficiency. Characterization of nano-geopolymer materials after column testing Transmission electron microscopy (TEM) and X-ray diffraction analysis (XRD) analysis of selected reacted adsorbent natural Ecuadorian (NatAllo) allophane were done.

Keywords: Novel, Geo-polymer, Water-remediation, Techniques

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LESSONS LEARNT FROM LIFE CYCLE ASSESSMENT OF ADVANCED WASTEWATER TREATMENT PROCESSES

Ferenc E. Kiss
Faculty of Technology Novi Sad, University of Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia
fkiss@uns.ac.rs

Wastewater treatment plants (WWTPs) play a pivotal role in minimizing environmental pollution by effectively treating wastewater and mitigating the release of contaminants into the environment. Despite their crucial function, WWTP operations inherently carry an environmental footprint, stemming from resource and energy consumption, as well as the discharge of pollutants. This holds true for advanced wastewater treatment processes as well, which often entail significant demands in terms of chemical usage, energy consumption, and may give rise to harmful intermediates and residual byproducts (such as metal ion-containing sludge or exhausted solid catalysts).
In this context, life cycle assessment (LCA) emerges as a valuable tool for comprehensively analyzing the environmental impact of WWTPs. By adopting a life cycle approach – from resource extraction to final disposal – LCA ensures the thorough examination of all stages and their subsequent environmental implications. Consequently, this methodology identifies environmental hotspots and potential trade-offs across various categories of environmental concern.
To shed light on the environmental rationale behind advanced wastewater treatment technologies like ozonation, activated carbon adsorption, membrane filtration, and solar and UV-based treatments, aimed at reducing the ecotoxicity potential of priority substances and contaminants of emerging concern (CECs), this study presents a thorough review of past LCAs. The primary objective of this research is to identify the strengths and weaknesses of specific advanced wastewater treatment processes concerning their environmental impacts, facilitating a comparative analysis and offering insights into the most sustainable processes for future scaling-up.

Keywords: Advanced wastewater treatment, Life cycle assessment, Environmental impacts.

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ROLE OF A HIGH-RESOLUTION MASS SPECTROMETRY IN INVESTIGATING PROCESSES FOR REMOVAL OF CONTAMINANTS OF EMERGING CONCERN FROM WATER

Igor Antić**, Jelena Živančev, Maja Buljovčić, Dušan Rakić, Nataša Đurišić-Mladenović
University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia,
**antic@tf.uns.ac.rs*

Estimating human exposure to an environmental ”cocktail” of chemicals is becoming one of the biggest challenges in modern science. The first and highest obstacle on that path is a reliable determination of as many as possible contaminants of emerging groups (CECs) with versatile physico-chemical properties present in environmental resources in trace amounts. CECs is a vast group of chemicals with unknown or suspect toxic effects that are currently not regulated, controlled, or routinely monitored in the (aqua) environment. Discharge from wastewater treatment (WWT) plants is recognized as one of the most important sources of numerous CECs in the environment, as conventional WWT plants are not designed to remove such micropollutants. Many processes, including physical (adsorption, membrane filtration), chemical (ozonation and other advanced oxidation processes (AOPs), including O_3/UV, UV/H_2O_2, Fenton and Fenton-like oxidation, etc.), and biological (application of pure or mixed cultures) have been investigated for removal of CECs from wastewaters as potential quaternary WWT process. Some of the mentioned treatments may result in transformation of parent compounds into even more polar and mobile products than their precursor chemicals and sometimes with increased toxicity; these transformation products are also considered as CECs. This is why it is of paramount importance to have robust analytical methodologies to investigate the presence of a wide range of CECs including their TPs in treated wastewaters to obtain full scale of the treatment efficiency. In the last decade, a new horizon has opened with the development of powerful instrumental techniques based on high-resolution mass spectrometry (HRMS) and data processing software. The availability of many acquisition modes together with high mass accuracy and resolution of HRMS measurements enable wide-scope suspect and non-target screening (NTS) of thousands of compounds. Additionally, retrospective analysis of archived HRMS data sets, allows identification of CECs that have not been in focus during the first data processing. This work aims to indicate the role of HRMS in investigating the efficiency in removal process for CECs in water. The challenges of CECs identification and quantification will be emphasized as during the HRMS NTS analysis thousands of chemical features with specific retention time and mass spectra can be detected. Processing of such data sets demands the latest software solutions, trained laboratory analysts for implementing various data interrogation steps (blank subtraction, replicate analysis, peak alignment), and tentative annotation of detected features with relevant HRMS databases, but it offers an extensive chemical profile of water samples, inevitable for further contaminants prioritization and risk assessment.

Keywords: Compounds of emerging concerns, Transformation products, HRMS, Suspect screening.

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ORAL PRESENTATIONS

ENHANCING THE EFFICIENCY OF LOW-PRESSURE MEMBRANE SEPARATIONS USING 3D PRINTED SPACERS

***Szabolcs Kertész*[1*], Imre Vajk Fazekas[1], Martin Trancsik[1], Aws N. Al-Tayawi[2], József Richárd Lennert[3], Sándor Beszédes[1], József Csanádi[4], Tamás Szabó[5], Cecilia Hodúr[1], Gábor Veréb[1], Zsuzsanna László[1]**

[1]*Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary, *kertesz@mk.u-szeged.hu*

[1]*Doctoral School of Environmental Sciences, University of Szeged, Szeged H-6725, Hungary*

[3]*Department of Power Electronics and E-Drives, Audi Hungarian Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary*

[4]*Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary*

[5]*Department of Physical Chemistry and Materials Science, Faculty of Science and Informatics, University of Szeged, Szeged H-6720, Hungary*

Our research primarily focuses on investigating the flow hydrodynamics within different membrane modules and assessing the potential consequences of altering these dynamics on process parameters. Our overarching goal is to optimize the flow conditions in both a smaller, classical, statically stirred laboratory separation cell and a cross-flow Vibratory Shear Enhanced Processing (*VSEP*) device with a larger filter surface. To achieve this goal and mitigate membrane fouling, we aim to implement shear rate enhancement on the membrane surface using 3D printed elements. Specifically, we plan to insert specially designed (promoters) into the smaller module and (spacers) into the larger *VSEP* separation module. We consider it important to carefully select 3D printable materials suitable for producing promoters and comprehensively test their mechanical robustness. In this work, various 3D printed spacers were investigated using a specialized *VSEP* device during ultrafiltration of model dairy wastewater. Our goal is to compare the effects of mechanical module vibration with the integration of spacers into the module, both of which can significantly mitigate fouling tendencies in the polymer membranes used. Additionally, we were curious to explore whether improved results could be achieved through the use of further developed, redesigned shapes (shape testing) and the utilization of Polyethylene Terephthalate Glycol (PETG) material alongside Polylactic acid (PLA) (material testing). Compared to the control measurements, the results showed improvements in all cases when the spacer was inserted into the module, when module vibration was applied, and when both spacer and module vibration were used together.

Keywords: Dairy Wastewater, Ultrafiltration, Membrane Fouling Mitigation, 3D Printing and Design, Spacers

Acknowledgements: This study was financed by the Hungarian National Research, Development and Innovation Office, project NKFI-FK-142414.

EVALUATION OF FLOW DYNAMICS UTILIZING INTEGRATED 3D PRINTED TURBULENCE PROMOTERS FOR MITIGATION OF MEMBRANE FOULING

Aws N. Al-Tayawi[1], Hajnalka Csott[3], Nikolett Sz. Gulyás[1,4], József Richárd Lennert[5], Zsuzsanna Horváth Hovorka[2], Zsuzsanna László[3], Cecilia Hodúr[3], Szabolcs Kertész[3*]

[1]Doctoral School of Environmental Sciences, University of Szeged, Szeged H-6725, Hungary

[2]Department of Mechanical Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

*[3]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary, * kertesz@mk.u-szeged.hu*

[4]Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

[5]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary

The rapid expansion of human populations has led to an increased demand for water resources and subsequently heightened levels of wastewater production. Membrane fouling, a persistent challenge in membrane-based wastewater treatment technologies, necessitates innovative strategies to enhance operational efficiency. Mitigating membrane fouling is imperative for sustaining filtration efficacy, extending membrane longevity, and reducing operational expenses. This study investigates the integration of 3D printed turbulence promoters to ameliorate the performance of a classical laboratory-scale ultrafiltration (UF) cell/module employed in the treatment of dairy wastewater. Parameters including transmembrane pressure (0.2 - 0.4 MPa), stirring speed (0, 200 & 400 rpm), and membrane cut-off (10, 20 & 50 kDa) are systematically examined to optimize the filtration process. Experimental trials conducted on the UF equipment utilizing dairy model effluent enable the identification of optimal operating conditions, notably including a 20 kDa membrane, 0.3 MPa pressure, and 400 rpm agitation speed. Four distinct designs of 3D printed turbulence promoters, fabricated from diverse filament materials (e.g., PLA, TPU, stainless steel, resin), are assessed to evaluate their effects on permeate flux, membrane retention, and overall resistance. Results reveal that specific turbulence promoter configurations, particularly the 'PLA initial' and 'PLA mini' variants, substantially enhance permeate flux and organic compound retention. Subsequent analyses employing different printing filaments demonstrate resin as the most efficacious material, significantly enhancing both flux rates and overall resistance mitigation.

Keywords: Dairy Wastewater, Turbulence Promoters, Membrane Fouling Mitigation, 3D Printed Materials.

Acknowledgements: This study was financed by the Hungarian National Research, Development and Innovation Office, project NKFI-FK-142414.

ADVANCED OXIDATION PROCESSES FOR NATURAL ORGANIC MATTER AND EMERGING CONTAMINATS ABATEMENT IN WATER TREATMENT

Jelena Molnar Jazić**, Tajana Simetić, Marijana Kragulj Isakovski, Aleksandra Tubić, Jasmina Agbaba
University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21000 Novi Sad, Republic of Serbia
**jelena.molnar@dh.uns.ac.rs*

The quality of water sources is highly affected by the presence of natural organic matter (NOM) that significantly varies in composition depending on the location, presenting the main precursors of regulated and emerging disinfection by-products (DBPs). Alongside natural contaminants, the aquatic environment is becoming increasingly vulnerable due to the discharge of wastewater effluents and the widespread presence of contaminants of emerging concern (CECs). Water scarcity is already driving the urgent need for improved water treatment, highlighting the ability of advanced oxidation processes (AOPs) to treat various contaminants, surpassing the effectiveness of conventional technologies.
Application of ozonation and ozone based-AOPs including TiO_2/O_3, H_2O_2/O_3 etc. as well as UV-driven AOPs (UV/H_2O_2, UV/persulfates) led to the partial oxidation of the fulvic acid fraction, thereby increasing the hydrophilic content of NOM originated from groundwater and surface water. Utilization of AOPs resulted in an increase in the emerging nitrogenous DBPs formation during the subsequent chlorination compared to the raw water, while precursors of carbonaceous DBPs were reduced. The estimated removal of certain CECs from groundwater including benzophenone, 2-phenoxyethanol, butylated hydroxytoluene and benzoic acid by ozonation increased with increasing ozone dose (up to 1.0 g O_3/m^3) and was in the range 24-70%. Ozone and ozone-based treatments enable partial removal of chlorinated volatile organic compounds from groundwater. Combination of UV light with hydrogen peroxide, persulfate and peroxymonosulphate enables complete degradation of alachlor and 1,2,3-trichlorobenzene from natural water matrices and in the presence of different reactive radical species. Our preliminary research also indicates that organic sunscreen agents are prone to oxidative degradation in water mediated by hydroxyl and sulfate radicals.
Summarized results indicate that AOPs can effectively be applied in water treatment for natural organic matter reduction and emerging contaminants degradation in water, where sulfate radicals driven AOPs might be an attractive option to overcome the difficulties caused by water matrix effects. Special attention should be paid to the DBPs formation during the subsequent chlorination and measures to mitigate associated risks.

Keywords: Advanced oxidation processes, Water treatment, Disinfection by-products, Emerging contaminants

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ADDRESSING ARSENIC CONTAMINATION: A POLYMER–BASED NANOCOMPOSITE FOR WATER TREATMENT

Jasmina Nikić**, Malcolm A. Watson, Maja Vujić, Jovana Pešić, Jovana Jokić–Govedarica, Srđan Rončević, Jasmina Agbaba
University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia,
**jasmina.nikic@dh.uns.ac.rs*

Arsenic contamination in water sources poses a significant threat to public health and environmental sustainability worldwide. Traditional methods for arsenic removal often suffer from limitations such as high cost, chemical usage, and sludge generation. In recent years, polymer-based nanocomposites have emerged as promising materials for arsenic mitigation from water, offering cost-effective and sustainable treatment solutions. In this study, in situ coating of polyethylene powder (PE) with Fe and Mn nanoparticles was utilized to fabricate FM-polymer-based nanocomposite (PE-FM). Various characterization techniques were employed to analyze the structural and chemical properties of the nanocomposite, providing insights into its performance and efficacy. Successful coating of polyethylene with Fe and Mn was confirmed using BET, SEM-EDS, and FTIR techniques. The coating process increased the surface area of the PE (1.06 m^2/g) by a factor of three and the pore volume (0.003 cm^3/g) by a factor of two, suggesting the prepared nanocomposite should demonstrate improved adsorption capabilities. To evaluate the adsorption performance of FM-polymer-based nanocomposites for arsenic removal, batch experiments were conducted. Preliminary adsorption experiments indicate that while PE by itself is ineffective for arsenic removal, the novel FMBO nanocomposite efficiently removed both As(III) and As(V), achieving a high removal efficiency (over 90%). This study contributes to ongoing efforts to address arsenic contamination challenges and advance the development of innovative materials for clean water.

Keywords: Arsenic, Polymer, Nanocomposite, Fe and Mn nanoparticles, Water treatment

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DIELECTRIC MONITORING IN WASTEWATER-TREATMENT AND SLUDGE UTILIZATION PROCESSES

Zoltán P. Jákói*, Cecilia Hodúr, Sándor Beszédes
Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Moszkvai krt. 9, Szeged, Hungary
**jakoiz@mk.u-szeged.hu*

Our research presents an integrated approach to enhancing biogas production and organic matter removal in wastewater treatment, focusing on microwave (MW)-enhanced techniques applied to meat industry sludge and wastewater. We explored the efficiency of combining iron oxide (Fe_3O_4) nanoparticles with microwave irradiation and a microwave irradiation-enhanced Fenton-like method to assess their impact on anaerobic digestibility and chemical oxygen demand (COD). The combined application of microwave irradiation with magnetic iron oxide nanoparticles significantly increased the soluble chemical oxygen demand (SCOD, with an enhancement ratio above 1.5), enhanced the rate of biogas production, and tripled the total cumulative biogas volume, all while maintaining or slightly improving the biomethane content. Furthermore, the study of dielectric properties, including the dielectric constant and loss factor, measured during the treatments provided a novel method to evaluate the efficiency of these pretreatments, revealing a strong correlation ($r=0.9942$, $R^2>0.99$) with changes in SCOD. Simultaneously, the microwave-enhanced Fenton-like oxidation process demonstrated its potential in reducing the high initial COD (1568 mgL-1) found in meat industry wastewater. Adjustments in the intensity of MW irradiation and the dosage of H_2O_2 / $FeSO_4$ were crucial, with higher settings leading to significant COD reductions and nearly a threefold increase in the dielectric loss tangent (tanδ). Specifically, applying 60 kJ of microwave energy with a 0.14 mgFe^{2+}/mgCOD dosage resulted in more than 40% COD removal efficiency. The research findings underline the advantages of using microwave-enhanced methods in wastewater treatment, illustrating how operational parameters such as MW energy intensity and chemical dosages critically influence treatment outcomes, thereby offering reliable solutions for improving biogas production and organic matter reduction in industrial wastewater treatment.

Keywords: Wastewater treatment, Sludge utilization, Microwave irradiation, Dielectric measurement, Biogas production.

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ADSORPTION KINETICS OF ORGANIC POLLUTANTS ON MICROPLASTIC FIBERS IN WATER

Maja Vujić*, Vasiljević Sanja, Tajana Simetić, Jelena Molnar Jazić, Marijana Kragulj Isakovski, Jasmina Agbaba, Aleksandra Tubić*

University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21000 Novi Sad, Republic of Serbia

**maja.loncarski@dh.uns.ac.rs*

Microplastics, characterized as plastic particles smaller than 5 mm, are becoming an increasingly prevalent and concerning environmental pollutant. Once they enter water environments, microplastics absorb diverse pollutants, transforming into carriers of hazardous substances. The textile industry and domestic washing of synthetic textiles are the primary contributors to microplastic fibers in water, making them one of the dominant forms of microplastics. While many studies have suggested that washing clothes is a major source of microplastics, only few have investigated the impact of mechanically drying clothes and textiles. The main objective of this study was to investigate the adsorption kinetics of specific polycyclic aromatic hydrocarbons (PAHs) onto microplastic fibers in water. Batch adsorption experiments were carried out under laboratory-controlled conditions. The attained results indicated that the highest adsorption rate was determined for adsorption of pyrene and fluoranthene on microplastic fibers isolated from material collected on drying machine filter, where 101.2 μg/g and 135.2 μg/g, respectively. The obtained results of this adsorption study also revealed that the adsorption affinity of selected PAHs on microplastic fibers is predominantly regulated by the physicochemical characteristics of the selected compounds and the structural organization of molecules. These results highlight the significant role of microplastic fibers in transporting organic pollutants in the environment and water systems.

Keywords: Organic pollutants, Microplastic fibers, Kinetic, Adsorption

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REMOVAL OF MICROPOLLUTANTS FROM WATER USING HYDROCHAR OBTAINED WITH PROCESS WATER RECIRCULATION

Marija Šobić*[1*], Mirjana Petronijević[1], Sanja Panić[1], Igor Antić[1], Jelena Živančev[1], Milan Tomić[2], Nataša Đurišić-Mladenović[1]

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, *sobicmarija@gmail.com*

[2]*University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, Novi Sad, Serbia*

Pharmaceuticals and pesticides, recognized as organic contaminants of emerging concern (CECs), are detected in surface water, wastewater, and groundwater. They enter the environment through human activities, primarily during manufacturing and application, posing risks to ecosystems and human health. Despite their low concentrations, their widespread presence raises concerns. Effective removal processes are crucial to protect water sources and the food chain. One of the processes to effectively remove pollutants simply and economically is adsorption. The adsorbents that have attracted special attention in recent decades for the removal of these compounds are hydrochars (HC). HC are generated through the hydrothermal carbonization (HTC) of different biomass. In the HTC process, subcritical state process water serves as the solvent to transform biomass into solid HC and liquid by-product. The resulting liquid by-product is laden with organic compounds (such as polyphenols, flavonoids, and dietary fibers) and inorganic elements, and could pose environmental risks if not managed correctly. To prevent environmental contamination and circumvent the costs of elaborate purification, one strategy is the recirculation of process water within the HTC cycle. Recirculating HTC process liquid enhances hydrochar's structure, increasing its efficiency in micropollutant removal from water. This recirculation enriches the hydrochar with organic compounds, boosting its adsorption capabilities through improved mass yield and structural properties, such as Brunauer-Emmett-Teller surface area and porosity, directly supporting sustainable water treatment goals.

In this study, the effectiveness of using HC as an adsorbent in the removal of selected micropollutants (cephalexin and propiconazole) from a model mixture prepared in deionized water was investigated. The HC was produced from waste wood biomass in the commercial reactor (at 300 °C) with and without process water recirculation. Using HC (5 g/L) the initial content of propiconazole of 10 µg/L was reduced for 81% after 2 h of reaction, while the removal efficiency increased by 85% using HC obtained with process with water recirculation. At the same reaction conditions, the removal of cephalexin improved from 61 to 69% by using HC obtained with process water recirculation, versus HC obtained without water recirculation. These findings imply that the enhanced adsorption capability and effectiveness of HC in water purification might be expected if HC was obtained with process water recirculation. This could be attributed to the improved structure of HC in the case of water recirculation; however, this conclusion has to be proved in further experiments broaden also to other micropollutants and the experimental conditions.

Keywords: Cephalexin, Propiconazole, Hydrochar, Recirculated process water, Adsorption

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PRODUCTION OF BIOACTIVE (ANTIOXIDANT AND ANTIBACTERIAL) PEPTIDES FROM SOYBEAN MILK PROTEINS BY AN ENZYMATIC MEMBRANE REACTOR

***Arijit Nath*[1]*, Geremew Geidare Kailo[1], Abraham Amankwaa[1], Gabriella Kiskó[2], András Koris[1]**
[1]*Department of Food Process Engineering, Institute of Food Science and Technology, Hungarian University of Agriculture and Life Sciences, Ménesi St 44, HU-1118 Budapest, Hungary*
**arijit0410@gmail.com*
[2]*Department of Food Microbiology and Biotechnology, Institute of Food Science and Technology, Hungarian University of Agriculture and Life Sciences, Somlói st 14-16, HU-1118 Budapest, Hungary*

Soybean (*Glycine max*) has long been recognized as sources of high-quality protein and considered the largest edible protein source around the world. Unfortunately, soybean proteins are listed among the “big 8” allergens due to the presence of linear and conformational epitopes in protein structure. Different subunits of soybean proteins contain IgE- and IgG-binding B-cell epitopes. It was recognized that food protein-derived bioactive peptides with unique biological values have been distributed to large numbers of consumers. Soybean protein-derived peptides play an important role in the regulation of metabolic pathways and have a significant contribution in the modulation of metabolic syndrome
Antioxidant and antibacterial peptides were produced from proteins from soybean milk through enzymatic membrane reactor. Enzymatic hydrolysis of soybean milk proteins with papain was performed in a stirred-tank temperature-controlled advanced bioreactor, operated with batch mode. Effect of initial concentration of papain (0.0008 – 0.0128 g/L) and reaction temperature (30 – 60 ^{o}C) were studied for soybean milk protein hydrolysis. In later exercise, a membrane bioreactor (a bioreactor with an external cross-flow membrane separation unit) was adopted for continuous production of antioxidant and antibacterial peptides from proteins from soybean milk proteins. The membrane bioreactor was operated for 12 hours with constant feeding. A ceramic-made tubular ultrafiltration membrane with molecular weight cut-off 5 kDa was placed inside the membrane house. In membrane separation process, a constant trans-membrane pressure (TMP) 3 bar and retention flow rate 100 L/h were adopted. A static turbulence promoter was placed in membrane tube and its effects on separation process was investigated.

Percentage degree of hydrolysis of protein in soybean milk was enzyme dose-dependent manner. However, the degree of hydrolysis was increased due to change of reaction temperature from 30 °C to 60 °C with enzyme concentration 0.0064 g/L and was reduced when hydrolysis reaction was performed with enzyme concentration 0.0032 g/L at hydrolysis temperature 60 °C. Antioxidant capacity of enzyme-treated milk had similar trend with degree of hydrolysis. Antibacterial activity of enzyme-hydrolyzed milk proteins against *Bacillus cereus* was proven. Permeate flux was reduced with process time due to the formation of concentration polarization on membrane surface. Positive effects of static turbulent promoter in respect of higher permeate flux and lower energy consumption in filtration process were proven. Peptides having antioxidant capacity and antibacterial activity against *Bacillus cereus* in membrane permeate in continuous way were achieved.

Keywords: Soybean milk protein, Enzymatic hydrolysis, Enzymatic membrane reactor, Antioxidant peptide, Antibacterial peptide

POSTER PRESENTATIONS

APPLICATION OF PHYSICALLY ACTIVATED BIOCHAR FOR THE REMOVAL OF PHENOL FROM WATER

***Aleksandra Adamović*[1*], Mirjana Petronijević[2], Saša Savić[1], Sanja Panić[2], Sanja Petrović[1], Nataša Đurišić-Mladenović[2]**

[1]*University of Niš, Faculty of Technology, Bulevar Oslobođenja 124, 16000 Leskovac, Serbia*
**aaleksandra17@hotmail.com*
[2]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*

Various industries discharge large amounts of wastewater containing phenol as a primary organic pollutant. To prevent environmental pollution, different treatments are used to remove phenol from wastewater. Adsorption using sustainable materials is considered to be one of the most effective methods for phenol removal. Biochar, due to its essential characteristics, such as high specific surface area and porosity, can be used as an efficient adsorbent for the removal of various organic pollutants from wastewater. Since pristine biochar typically has a low specific surface area, various activation procedures are necessary for further porosity development and improving its adsorption capability. The most commonly used processes for the preparation of activated biochar are physical and chemical activation. For physical activation, the pristine biochar is partially gasified, usually by steam or carbon dioxide at temperatures in the range of 700–900°C, while for chemical activation, the biomass is impregnated with a chemical (H_3PO_4, $ZnCl_2$ or Na or K hydroxides or salts) before carbonization step.

The aim of this research was to investigate the adsorption capacities of pristine and physically activated biochar for the removal of phenol from water. The pristine biochar was produced from the sawdust of beech wood by slow pyrolysis in a nitrogen atmosphere at 700°C for 2h. In order to prepare the activated form of biochar, the pristine sample was subjected to a stream of CO_2 at 700°C for 1h. The achieved adsorption capacity of pristine biochar for phenol removal was 48% in the first 15 min of water treatment, while the efficiency of the process increased to 82% after 3h. On the other hand, physically activated biochar showed significantly higher adsorption efficiency for phenol removal of 95% under the same reaction conditions. The obtained results indicate that the applied CO_2 activation procedure represents a promising route for the production of biochar with excellent adsorption performances for phenol removal from water.

Keywords: Biochar, CO_2 activation, Water treatment, Phenol removal, Adsorption

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POTENTIAL OF HYDROCHAR AS BIOSORBENT FOR HEAVY METAL IONS REMOVAL FROM WATER

***Marco Barbanera*[1]*, Alessandro Cardarelli[1], Vesna M. Vasić[2], Dragana V. Lukić[2]**
[1]University of Tuscia, Department of Economics, Engineering, Society and Business Organization, 01100 Viterbo, Italy
**m.barbanera@unitus.it*
[2]University of Novi Sad, Faculty of Technology Novi Sad, Bul. cara Lazara 1, 21000 Novi Sad, Serbia,

Pollution of aquatic ecosystems with heavy metals, including drinking water resources and water intended for consumption, is one of the most critical issues worldwide. Heavy metals can be derived from both natural and anthropogenic sources. Anthropogenic sources include industrial production, mining industry, coal combustion, waste disposal, and agricultural soil fertilization. Over the last two decades, a wide range of treatment technologies have been investigated for the removal of heavy metals from water. Biosorption showed good performances in adsorbing these pollutants present in water at trace levels.
Hydrochar has garnered significant attention as adsorbent material, but further investigation is required into the alteration of material properties caused by the recirculation of process liquid. This is especially pertinent given that commercial hydrothermal carbonization (HTC) typically employs HTC process liquid recirculation to both preheat the feedstock and reduce wastewater accumulation.
Therefore, this study aimed to investigate the impacts of process liquid recirculation up to 4 cycles, with a specific focus on the adsorption capacities of Cr(VI) and Cu(II) ions from water throughout consecutive recycles. HTC of the exhausted chestnut from the tannin extraction industry was performed at a fixed temperature (270 °C), a fixed residence time (60 mins) and a solid/liquid mass ratio of 1/10.
The adsorption studies were conducted in bach conditions. Obtained results showed good adsorption properties for the removal of Cr(VI) ions, while binding of Cu(II) ions was negligible. Further investigation will be focused on kinetic studies for the Cr(VI) ions, and evaluation of hydrochar properties for the removal of micropollutants from water.

Keywords: Hydrochar, Hydrothermal carbonization, Heavy metals, Biosorption, Wastewater treatment.

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INFLUENCE OF SELECTED CARRIER MATERIALS ON NATURAL COAGULANT PRODUCTION YIELD

***Sanja Cojbasic*[1*], Maja Turk Sekulic[1], Jelena Prodanovic[2]**
*[1] University of Novi Sad, Faculty of Technical Sciences, Department of Environmental Engineering and Occupational Safety and Health, Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia , *sanjaradovic@uns.ac.rs*
[2] University of Novi Sad, Faculty of Technology Novi Sad, Bulevar Cara Lazara 1, 21 000 Novi Sad, Serbia

Spray drying technology has been abundantly used in practice for the efficient production and preservation of different powdered products. Present study focuses on the production of natural coagulant (from common bean seeds) by spray drying process (under the temperature of 120-125˚C and pressure of 3.2 bar). The study evaluates influence of the addition of two carrier materials, namely, maltodextrin (16 DE) and gum Arabic, on the final product yield. Carrier materials were added in two ratios (50 and 100 %) to liquid coagulant extracts before drying process. In total, 16 different products were obtained using two extraction types (conventional solid/liquid and ultrasound), two extraction agents (distilled water and 0.5 M NaCl solution) and drying without or with carrier material addition. The results showed that both maltodextrin and gum Arabic addition can affect production yield, but the type of affection depends not only on carrier material type, but also on the type of the extraction and extraction agent used to produce the liquid coagulant extracts. A production yield increase was the highest when 100% of gum Arabic was added to the liquid extract obtained by conventional solid/liquid extraction and distilled water as an extraction agent (yield increased for almost 20% comparing to the same samples dried without carrier agent addition). On the contrary, when 100% maltodextrin was used for the same liquid extract, there was even a slight, but insignificant decrease (around 5%) in the production yield. An opposite situation was observed in case of drying liquid extracts obtained by ultrasound extraction and extracted with distilled water. Concerning liquid samples obtained by salt solution, an insignificant change in the production yield was observed when either one of the carrier materials was used during spray drying process. This might be attributed to the better extraction ability of salt solution comparing to distilled water and consequently higher dry matter content. Finally, it could be concluded that the addition of carrier material to spray drying process for the natural coagulant production could affect production yield (which could be attributed to better preservation of bio-active compounds of natural coagulant). However, the effect not only depends on carrier material choice but also on the type of liquid extract that has been added to. Future studies and applications should pay attention on careful selection of those variables to achieve the most preferable results.

Keywords: Spray drying, Green solutions, Wastewater treatment, Maltodextrin, Gum Arabic

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APPLICATION OF LEDS IN UV/CHLORINE AOPS FOR THE TREATMENT OF AQUEOUS SOLUTIONS OF POPS SUCH AS PHARMACEUTICALS

Anett Čović*, Luca Farkas, Constance Csaplár, Teodóra Dragić and Tünde Alapi
Department of Molecular and Analytical Chemistry, University of Szeged, H-6720 Szeged, Dóm tér 7, Hungary,
**alapi@chem.u-szeged.hu*

The production of adequate quality drinking water is a universal problem today, partly due to the biologically active and persistent organic pollutants that cannot be removed by conventional water treatment processes. In water disinfection, the most common method is chlorination, using Cl_2 or HOCl as a disinfectant. In addition, ClO_2 receives more and more attention due to the reduced risk of the formation of toxic byproducts, such as chloramines. Irradiation of the disinfectants with adequate UV light results in reactive oxygen (ROS) and chlorine-containing species (RCS) (e.g. •OH, Cl•, ClO•, Cl_2•$^-$, $^1O_2$). In this way, besides disinfection, the elimination of organic substances via radical-based reactions became possible.
In this work, the efficiency of the UV/ClO_2 and UV/FAC (FAC: freely available chlorine, i.e. the sum of HOCl and OCl^-) processes were investigated for the elimination of trimethoprim antibiotic. The wavelength relating to the ClO_2 absorption maximum is 359 nm, and the value of molar absorbance is ~1200 M^{-1} cm^{-1}. LED having an emission maximum of 367 nm, was used as a light source to initiate the radical formation via direct photolysis of ClO_2. For the UV/FAC process, considering the UV-Vis absorption spectrum of HOCl and OCl^-, the LEDs emitting at 265 and 275 nm are a good alternative to traditional low-pressure mercury vapor lamps emitting 254 nm photons. The ratio of protonated and deprotonated forms (pK_a = 7.54) determines the absorption properties of the treated solution and the steady-state concentration of the formed radicals, such as •OH, Cl•, Cl_2•$^-$ and ClO•.
The effect of ClO_2 and FAC dosage (3 - 14 ppm), pH (from pH 3.0 to pH 9.0), and light intensity by changing the electric power of LED (1.4 - 6.4 W), and matrix effect using biologically treated domestic wastewater were investigated. Radical scavengers were used to investigate the role and contribution of various reactive species to the transformation of trimethoprim. A special attention was paid to the formation of chlorinated organic products, chlorite and chlorate ions and change of ecotoxicity.

Keywords: LED, Antibiotic, Advanced oxidation processes-AOPs, UV/chlorine, ClO_2, HOCl

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PREDICTION THE PHOTOCATALYTIC DEGRADATION RATE OF DICLOFENAC BY ARTIFICIAL NEURAL NETWORKS

S. Roy, L. Das Samanta*

[1]Haldia Institute of Technology, ICARE Complex, Hatiberia, Haldia, Posta Code: 721657, Purba Medinipur, West Bengal, India

**lipikadas24@gmail.com*

Photocatalytic degradation with its reaction kinetics in general is very complex in nature. For the investigation, a model chemical called diclofenac (DCF) was utilized. Artificial neural networks (ANNs) have been used to reduce complexity because of their relevant, trustworthy, and resilient nature, which allows them to stop the nonlinear interactions between variables in complex systems. The current study uses an artificial neural network model to predict photocatalysis efficiency. The percentage degradation of DCF is chosen as the output, while independent factors such catalyst loading, pH, reaction duration, temperature and beginning DCF concentration are employed as the input parameters to optimize network performance. The experimental design of the variables under ultraviolet (UV) light yielded the percentage degradation of DCF. To locate the most suitable and reliable network, various algorithms with transfer functions have been investigated. The optimal quantity of neurons was determined using on the training and prediction set's mean square error's (MSE) lowest value. The percentage residual error (RE %) of ANN model was calculated. The maximum percentage degradation of DCF was achieved 93.41 using 0.65 g/L catalyst weight, concentration of reactant 50 ppm at pH 7 under room temperature. It has been obvious that ANN has promise for predicting the proportion of DCF degradation.

Keywords: Titania-zirconia nanocomposite, Advanced Oxidation Process, Photocatalysis, Diclofenac, Artificial neural network

ACTIVATION OF PEROXYMONOSULFATE WITH BIOCHAR - ADSORPTION AND ELIMINATION OF TRIMETHOPRIM ANTIBIOTIC FROM WATERS

Dinesh Chandola*[1], *Erik Sinkovics*[1], *Zsuzsanna László*[2] *and Tünde Alapi*[1]
*[1]1Department of Molecular and Analytical Chemistry, University of Szeged, H-6720 Szeged, Dóm tér 7, Hungary, *alapi@chem.u-szeged.hu*
[2] Department of Biosystem Engineering, Faculty of Engineering, University of Szeged, Moszkvai Blvd. 9., H-6725 Szeged, Hungary

In recent times, biochar has been explored as a catalyst for removing organic contaminants in persulfate-based advanced oxidation processes (PS-AOPs). During this process, biochar acts as a catalyst, reacting with the oxidant to generate reactive oxygen containing species ($SO_4^{\bullet-}$, $^{\bullet}OH$ and $^1O_2$ etc.) with high oxidation potential, thereby facilitating the degradation of organic contaminants.
In this study, waste biomass like corn-cob (CC), poplar wood (PW), and grass-pellet (GP) were used to produce biochar. Various pyrolysis temperatures ranging from 400 °C to 800 °C were employed, and ball-milling (BM), a physical method was used to modify the biochar. Analytical techniques such as FT-IR, Raman spectroscopy, and N_2 adsorption-desorption were employed to evaluate the physicochemical properties of the biochar. Experimental parameters including biochar and PMS doses, the influence of different ions (HCO_3^-, Cl^-, and humic acid), various radical scavengers and the impact of biologically treated domestic wastewater as matrix were investigated.
Enhanced degradation efficiency with decreased adsorption capacity was observed as pyrolysis temperature increased from 400°C to 700 °C, emphasizing the significant influence of pyrolysis temperature on biochar's catalytic properties. The degradation efficiency of TMP depended on the raw material and varied in this order GP-BC (93.3%) > CC-BC (78.25%) > PW-BC (71.51%) using 2 mM and 3 g/L PMS and biochar (700 °C) dose, respectively. Ball milling highly enlarged the specific surface area, enhanced the adsorption efficiency, accelerated the degradation, and reduced the required dose of biochar and PMS to 0.5g/L and 0.2 mM. This suggests that ball-milling has led to surface modification and the creation of new active sites, enhancing the performance of biochar.
The radical scavenger study confirmed radical ($SO_4^{\bullet-}$ and $\bullet OH$) and non-radical species ($^1O_2$) involvement in TMP degradation. GP-BMBC was used to investigate the effect of biologically treated wastewater as a matrix; the degradation of TRIM was inhibited slightly in this case. However, the higher dose of biochar and PMS can compensate for the negative matrix effect. The inhibition effect of matrix components was also studied, and TRIM degradation was moderated by inorganic ions (HCO_3^- and Cl^-) and humic acid (HA) by different degrees. Furthermore, the GP-BMBC was used for PDS and H_2O_2 activation, but only 17 and 8% TMP was transformed. Further studies are needed to explore reactor design and the practical application of biochar coupled with PS systems.

Keywords: Biochar, Antibiotic, Water treatment, Persulfate

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COMBINED ION EXCHANGE AND MICROFILTRATION

Marijana Dragosavac
Loughborough University, Ashby road, LE113JA, UK
m.dragosavac@lboro.ac.uk

The purpose behind this work is to produce polystyrene-divinylbenzene cation exchange resin particles at various sizes, smaller than are conventionally available, and to use them in a microfiltration process; comparing the results with conventional column operation. In the seeded microfiltration process, surface microfilters with slots without internal tortuosity were used to minimize fouling. A filtration flux rate of 3432 l m^{-2} h^{-1} was achieved. Rates of copper sorption on to ion exchange resin were found to be dependent on mass transport limitations due to aqueous film diffusion and internal particle diffusion. For prediction of copper sorption a model that takes into account both film and internal diffusion was used. Microfiltration combined with ion exchange has the advantage of very fast kinetics, when compared to column use, and may provide better utilization of the resin particle, depending on the internal diffusion coefficient of the transferring species within the particle.

Keywords: Microfiltration, Slotted membranes, Ion exchange

LIGNIN DERIVED FROM CYNARA CARDUNCULUS AS AN EFFICIENT BIOSORBENT FOR CHROMIUM(VI) ION REMOVAL FROM WATER

***Jorge Gominho*[2], Ana Lourenço[2], Ricardo A. Costa[2], Duarte M. Neiva[2], Vesna M. Vasić[1*], Dragana V. Lukić[1], Marina B. Šćiban[1]**

[1]*University of Novi Sad, Faculty of Technology Novi Sad, bul. cara Lazara 1, 21000 Novi Sad, Serbia, *vesna.vasic@uns.ac.rs*

[2] *Centro de Estudos Florestais, Laboratório Associado TERRA, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal*

The development of industry, combined with inadequate treatment of waste water, has led to increased pollution of water sources with heavy metals, which is a growing problem both from the point of view of environmental protection and the provision of drinking water. The removal of heavy metals from water has been the subject of much research worldwide, and various techniques have been developed and implemented for this purpose. In the last two decades, research in the field of biosorption has been intensified. In this paper, the possible use of lignin obtained from *Cynara cardunculus* as a biosorbent for the removal of Cr(VI) ions from water was investigated.

The lignin used in this study was isolated from kraft black liquor. H_2SO_4 was used to lower the pH from 12 to 2. The precipitated lignin was recovered by centrifugation (5000 rpm), washed with H_2O and lyophilised. Batch experiments were performed by mixing 0.5 g/L adsorbent (lignin) and chromium solution of different initial concentrations (5-1000 mg/L) at pH 2 for 24 h. The results showed that the Langmuir model appeared to be the best to fit the experimental data with the qmax of 370.85 mg/g and R^2=1. Cynara lignin proved to be a promising biosorbent for the removal of Cr(VI) from water.

Keywords: Biosorption, Lignin, Chromium, Cynara cardunculus

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JUTE FABRIC WASTE AS A PROMISING ADSORBENT FOR HEAVY METAL IONS AND ORGANIC DYES: A COMPREHENSIVE REVIEW

Aleksandra M. Ivanovska
University of Belgrade, Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Republic of Serbia,
aivanovska@tmf.bg.ac.rs

The Food and Agricultural Organization of the United Nations has ranked jute as the second most significant natural fiber, with an annual world production of 3.46 million tons in 2021. Jute fibers are renowned for their remarkable mechanical, antistatic, and insulating properties, as well as their antimicrobial activity. These attributes render jute sacking bags ideal for packaging agricultural commodities. However, the escalated production of such common products yields a substantial amount of jute waste in fabric form, contributing to landfill occupation and exacerbating global warming. A huge amount of jute fabric waste derived from the packaging industry has never been subjected to any treatments meaning that jute fiber structure and properties remain unchanged. Thanks to its heterogeneous chemical composition comprising cellulose, hemicelluloses, lignin, and extractives, along with its layered fiber structure, and diverse functional groups, waste jute presents a promising candidate for various modifications that hold the potential to prolonging its lifetime and integrate it into the circular economy concept. This endeavor aligns with the objectives outlined in the EU Strategy for Sustainable and Circular Textiles, fostering the advancement of the textile sector through reusing and recycling initiatives.
This study represents a comprehensive review of the impact of different chemical modifications, such as alkali treatment using an aqueous solution of NaOH, oxidation employing an aqueous solution of $NaIO_4$, or treatment with chitosan, on the adsorption potential of jute fabric waste for two prevalent water pollutants: heavy metal ions and organic dyes. The findings demonstrate that alkali treated jute fabric waste can adsorb up to 15.04 mg/g of anthraquinone dye C. I. Acid Blue 111, while the maximum adsorption potential for Ni^{2+} and Cu^{2+} is found to be 10.21 mg/g. On the other hand, jute fabric waste oxidized with 0.4% $NaIO_4$ for 120 min demonstrated a calculated maximal adsorption potential of 12.86 mg/g for organic dye Congo Red. Furthermore, treatments involving natural polysaccharides like chitosan enhance the sorption properties of jute fabric waste, as evidenced by an adsorption potential of 10.13 mg/g for dye Reactive Orange 16. These findings collectively underscore the potential of jute fabric waste as a promising adsorbent for various heavy metal ions and dyes.

Keywords: Jute, Adsorbent, Heavy metal ions, Organic dyes

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REMOVAL OF PHENOL FROM WATER BY USING FREE AND IMMOBILIZED HORSERADISH PEROXIDASE CATALYZED PROCESS

Milan P. Nikolić**, Slobodanka Stanojević-Nikolić
Faculty of Agronomy in Čačak, University of Kragujevac, Cara Dušana 34, 32102 Čačak, Serbia,
**milanik@kg.ac.rs*

The purpose of this investigation is to explore the application of commercial peroxidase obtained from horseradish, to remove the phenol from water by the catalytic oxidation of phenol. In the first case, phenol was removed by using free enzymes dissolved in water solution. In the second case, an electrochemical biosensor based on immobilization of native peroxidase on screen-printed carbon electrode which is used as a working electrode. A headspace solid phase microextraction (HS-SPME) as the extraction technique and gas chromatography coupled with mass spectrometry was utilized for the determination of organic micropollutant concentrations. To prevent potential desorption of enzyme, a Nafion solution of different concentrations (0.1 and 0.5 wt.%) was applied onto the enzyme layer. The mechanism of phenol oxidation and the influence of Nafion presence and concentration on the phenol oxidation process were examined using cyclic voltammetry. The influence of nanoparticle dopping on the electrochemical performances of enzyme-based biosensor electrode was also investigated. It was determined that phenol is oxidized to phenoxyl radicals, which polymerize and form insoluble precipitates, visually confirmed as well. The presence of diffusion limitations caused by the Nafion layer was observed, as confirmed by electrochemical impedance spectroscopy in the case of the Nafion layer obtained from a more concentrated solution. By incubating the native enzyme in a solution a high efficiency of phenol removal was achieved.
Based on these results, it was determined that peroxidase is a highly specific and efficient catalyst capable of selectively degrading the target pollutant without affecting other components in the effluent. From an environmental perspective, these enzymes are more acceptable due to their biodegradability.

Keywords: P*henol, Organic pollutants, Biosensor, Peroxidase*

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PRODUCTION OF ANTIOXIDANT AND ANTIBACTERIAL PEPTIDES FROM SOYBEAN MEAL BY AN ENZYMATIC MEMBRANE REACTOR

***Arijit Nath*[1]*, Geremew Geidare Kailo[1], Abraham Amankwaa[1], Gabriella Kiskó[2], András Koris[1]**
[1]Department of Food Process Engineering, Institute of Food Science and Technology, Hungarian University of Agriculture and Life Sciences, Ménesi St 44, HU-1118 Budapest, Hungary
**arijit0410@gmail.com*
[2]Department of Food Microbiology and Biotechnology, Institute of Food Science and Technology, Hungarian University of Agriculture and Life Sciences, Somlói st 14-16, HU-1118 Budapest, Hungary

The major byproduct in vegetable oil processing industry is defatted soybean meal contains 40–45 % (mass basis) protein. Its digestibility often reduced due to the presence of trypsin inhibitors. Although trypsin inhibitor activity is adequately reduced by the heat treatment, the allergenic effect of soybean meal proteins is one of limiting factor of its use. Therefore, production of hypoallergenic bioactive (antioxidant and antibacterial) peptides from defatted soybean meal were produced by an enzymatic membrane reactor.
In the first step, soybean meal poly-peptides were digested with serine protease trypsin (1,000-2,000 BAEE units.mg solid-1) in a bioreactor, operated at batch mode. After enzymatic digestion, low-molecular-mass peptides were purified with cross-flow flat sheet membrane (pore size 100 µm) and then with tubular ceramic ultrafiltration membrane (molecular mass cut-off 5 kDa). Effects of transmembrane pressure (TMP), ranging from 2-5 bar and the use of a static turbulence promoter within membrane tube to reduce the concentration polarization on the ultrafiltration membrane surface were examined. Filtration process was performed with volume concentration factor 2. Four-stage discontinuous diafiltration with membrane cleaning after each stage were considered. Membrane purified peptides were characterized with respect to molecular weight distribution, peptide sequences, antioxidant activity, antibacterial activity against *Bacillus cereus* and allergenic activity.
Optimum initial soybean meal concentration, temperature and pH for the enzymatic reaction were determined to be 75 g/L (offering total protein concentration 30 g/L), 40 ^{o}C and 9 respectively. It was found that the free energy change of the activation of enzymatic reaction was not thermodynamically favored and the activation of the enzymatic reaction was entropy driven. Positive effects of TMP and static turbulence promoter on protein permeation and permeate flux were proven. In the filtration process, TMP 3 bar with 3-stages discontinuous diafiltration were found as optimal. The approximate molecular weight of the membrane purified peptides were found to be ≤ 4.5 kDa by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) analysis. The decrease of allergenic property due to the tryptic digestion and membrane filtration were determined by an enzyme-linked immunosorbent assay method and it was found to more than 99.9%. Antioxidant capacity of membrane permeate peptides, obtained at optimum filtration condition was determined to be 343 µmol eqv ascorbic acid/ L. It was also found that the membrane purified peptides possessed antibacterial activity against *Bacillus cereus*.

Keywords: Soybean meal, Enzymatic membrane reactor, Low-molecular weight peptide, Antibacterial peptides, Antioxidant peptide.

APPLICATION OF LIGNOCELLULOSIC BIOSORBENT FOR SUGAR JUICE PURIFICATION IN FIXED-BED COLUMN

***Lidija E. Perović*[1*], Jelena A. Miljanić[1], Julija Šupljika[2], Ivan Zdjelarević[2], Nikola R. Maravić[3], Zita I. Šereš[3]**
[1]*Institute of Food Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia,*
**lidija.perovic@fins.uns.ac.rs*
[2] *Josip Juraj Strossmayer University of Osijek, Trg svetog trojstva 3, 31000 Osijek, Croatia*
[3] *Faculty of Technology, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*

Lignocellulosic biomaterial has been used as a natural cation exchanger. Due to eco-consciousness and sustainability-oriented development of technological processes, biosorption process has been developed with minimal ecological impact. The main goal of the biosorption process used as a pretreatment technology is obtaining the highest yield with optimal processing conditions. Following the rules of the circular economy is important to reach resource efficiency and industrial symbiosis. Therefore, sugar beet pulp, used as a biosorbent, has a polyfunctional surface eligible for treating Na, K and Ca-containing alkalized juice. Molassigenic metals are Na, K and Ca susceptible to form molasses. Biosorbent has been used in natural form. Through the concept of breakthrough curve, the performance of the fixed-bed column was described. A fixed-bed column packed with sugar beet pulp was designed to operate a continuous flow of the alkalized juice. The effect of bed depth, liquid flow and particle size of the biosorbent has been evaluated to reach the highest removal effect of the aforementioned molassigenic metals. The effect of bed height has the highest impact in combination with liquid flow. Higher bed depth resulted in higher breakthrough point time and at the same time higher amount of Na, K and Ca ions adsorbed. Increasing bed depth increases the number of active sites and ionic groups. Ions of Na was removed in the most successful percentage (74.19%), whereas calcium ions and potassium ions were less successfully removed (62.78% and 50.69%, respectively). All successful biosorption experiments have been done with the highest bed depth. The model of the alkalized juice pretreatment in fixed-bed columns was proven with model water containing the same metal ions dissolved in water. Breakthrough curves of both, real effluent and the synthetic water solution were similar, representing similar trends and behavior of the continuous biosorption process.

Keywords: Biosorbent, Fixed-bed column, Sugar juice, Purification

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REMOVAL OF CONTAMINANTS OF EMERGING CONCERN FROM WATER USING UV-H_2O_2 ADVANCED OXIDATION PROCESS

Mirjana Petronijević**, Sanja Panić, Jelena Živančev, Igor Antić, Dušan Rakić, Nataša Đurišić-Mladenović
University of Novi Sad, Faculty of Technology Novi Sad, Bul. cara Lazara 1, 21000 Novi Sad, Republic of Serbia,
**mirjana.petronijevic@uns.ac.rs*

The presence of contaminants of emerging concern, CECs, such as pharmaceutical active compounds, PhACs, and pesticides, in water resources, represents a potential risk to the environment and human health. Their emissions and environmental presence have not been regulated nor controlled. Conventional water treatment processes do not adequately address the removal of these compounds, so they remain behind in the treated water, so CECs can also contaminate the sources of public drinking water. Therefore, there is a need for the additional treatments for the effective removal of these pollutants. Advanced oxidation processes (AOPs) are promising approach for removal of CECs through their degradation via a radical-based mechanism.

In this work the efficiency of AOP with UV irradiance and oxidation with H_2O_2 (UV-H_2O_2) in CECs removal from synthetic water solution was investigated. The results obtained with the application of 20 mg H_2O_2/L and UV irradiation with low pressure Hg lamp were compared with the results obtained with UV photolysis alone. A mixture of 35 pollutants (19 PhACs and 16 pesticides) in concentration of 10 µg/L of each compound was used for the investigation. In the case of PhACs removal, the UV-AOPs proved to be a superior process compared to UV photolysis for the removal of about 50% of investigated compounds, with the highest efficiency in the removal of famotidine (53%), sotalol (54%), and cephalexin (68%). Utilization of UV photolysis alone resulted in better removal of ofloxacin (83%), ditriazem (66%), dichlofenac acid (28%); additionally, a significant removal of cephalexin (57%) was achieved. The applied UV treatments did not affect the content of clarithromycin, losartan, erythromycin and carbamazepine. Both processes showed an approximate efficiency in the removal of pesticides of up to 50%. Effective removal of linuron (49%), tebucanazole (36%), propiconazole (32%), and phorate (51%) was achieved by UV photolysis, while 50% removal of linuron, and 37% of phorate was achieved by applying UV-AOPs. Based on these results, it is not possible to draw a universal conclusion, and further process optimization is necessary.

Keywords: Contaminants of emerging concern (CECs), UV/H_2O_2 process, Water treatment.

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Cu^{2+} ADSORPTION FROM AQUEOUS SOLUTION BY WASTE EGGSHELL POWDER

***Sanja Petrović*[1]*, Saša Savić[1], Mirjana Petronijević[2], Bratislav Todorović[1], Staniša Stojiljković[1]**
[1]Faculty of Technology, University of Nis, Bulevar oslobodjenja 124, 16000 Leskovac, Serbia,
**milenkovic_sanja@yahoo.com*
[2]Faculty of Technology, University of Novi Sad, Bulevar cara Lazara 1, 21102 Novi Sad, Serbia

Nowadays research has shown that the efficiency of heavy metals removal from contaminated water by using natural waste unmodified or modified adsorbents is comparable to the efficiency of removal by using conventional adsorbents while the price is significantly lower. Adsorption of copper at a concentration of 50 ppm ($CuSO_4 \times 5H_2O$) was monitored in an ultrasonic at 40 kHz and batch system at a defined number of revolutions (150 rpm), room temperature (298 K) and pH 4.5. Aqueous copper solution in a volume of 100 mL was mixed on a magnetic stirrer together with a precisely defined mass of eggshell powder-1g with a particle size of 100 μm. Samples of aliquots were taken from the solution at certain time intervals (after 0.5, 15, 30, 45, and 60 min) and filtered through membrane filters, 0.45 μ. After the completion adsorption procedure, the concentration of Cu^{2+} was determined by inductively coupled plasma - optical emission spectrometry (ICP-OES) analysis. The results of the adsorption of Cu^{2+} by the eggshell powder in a time interval of 60 min demonstrated a higher adsorption of Cu^{2+} in the batch system (53.6%) compared to the ultrasonic system (43.2%). The largest amount of Cu^{2+} is adsorbed at the beginning of adsorption (5 min) and then decreases with increasing contact time between the adsorbent and the liquid phase in which cations are found. This behavior of adsorption of Cu cations is expected; in all cases it first takes place quickly, on the outer surface of the adsorbent particles, and then, over time, it takes place at the active sites inside the adsorbent pores.

Keywords: Adsorption, Eggshell, Copper.

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PHENOL REMOVAL FROM WATER SOLUTION USING PEROXIDASE EXTRACTED FROM POTATO PEEL

***Saša Savić*[1]*, Sanja Petrović[1], Mirjana Petronijević[2]**
[11]*University of Niš, Faculty of Technology, Bulevar Oslobođenja 124, 16000 Leskovac, Serbia*
**sasa.savic@tf.ni.ac.rs*
[2]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*

Phenol is the main pollutant in wastewater originating from industries such as petrochemical, pharmaceutical, and oil industries. In the past, various treatment methods have been used to remove phenol, such as adsorption, ion exchange, oxidation, and biological treatment. In the last decades, enzyme-catalyzed polymerization of phenol has been developed as a new methodology for phenol removal. Peroxidase is one of the most widely used enzymes in enzyme-assisted phenol removal processes. It is known as an enzyme that has catalytic ability over a wide range of temperatures, pH values, and pollutant concentrations. This study investigates the feasibility of employing unpurified peroxidase extracted from potato peel for phenol elimination from aqueous solutions. The influence of peroxidase, phenol, hydrogen peroxide, and polyethylene glycol (PEG) concentrations, as well as incubation time, temperature, pH value, and shaking rate on the efficiency of the phenol removal process, was comprehensively evaluated. The phenol removal efficiency was assessed via spectrophotometric monitoring of residual phenol levels in reaction mixtures. The highest achieved phenol removal efficiency is 97%. The results showed that the use of raw, unpurified peroxidase from potato peel can successfully replace commercial peroxidase and thereby significantly reduce the cost of the procedure. In addition, the presence of PEG as a peroxidase stabilizer showed little effect on the efficiency of phenol removal (3%), indicating that the extracted crude peroxidase is stable even without a commercial stabilizer, which could further cheapen the phenol removal process.

Keywords: Potato peel, Peroxidase, Phenol removal, Pollutant.

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THE MICROPLASTIC IS VISIBLE BY FLUORESCENCE UNDER STEREOMICROSCOPE

Živa Kolenc, Kaja Adamek, Sonja Smole Možina*, Anja Klančnik
Biotechnical Faculty, Chair of Biotechnology, Microbiology and Food Safety, Department of Food Science and Technology, UL, Jamnikarjeva 101,1000, Ljubljana, Slovenia
**sonja.smole@bf.uni-lj.si*

Plastics are valued in industry for their lightness, durability and versatility, but their overproduction, especially of single-use plastics and microplastics, is responsible for significant environmental pollution. Most plastics are difficult to recycle and the European Environment Agency is calling for a shift to circular and sustainable practices. Every year, around 370 million tons of plastic are produced worldwide, of which 6.3 billion tons become waste. Humans can ingest between 70,000 and 120,000 microplastic particles a year, mainly through the air, and those who mainly drink bottled water may ingest a further 90,000 particles. Microplastics, including fragments and pellets, are produced both during the degradation of larger plastics and during the direct manufacture of products such as cosmetics. Efforts to control and reduce their presence include EU regulations such as REACH, bans on microbeads in cosmetics and regulations for artificial sports surfaces.
Microplastics in the food production environment increase the surface area for colonization by microbial biofilms, as the food particles present promote their growth. Biofilms on microplastics can become vectors of microbial communities including potential pathogens and thus pose a potential risk to microbiological safety. Researchers continue to develop techniques to identify and study microplastics in the environment and in food systems. At the University of Ljubljana, Chair of Biotechnology, Microbiology and Food Safety, we focus on microplastics as carriers of pathogenic bacteria in the food chain and develop standardized methods for the detection of microplastics in various foods such as shellfish, chicken and milk. Fluorescence analysis can be used to detect and characterize microplastics, although it is less precise and widespread than spectroscopy. Fluorescence analysis of synthetic polymers stained with Nile red enables the differentiated emission of fluorescence under certain light filters; for example, polystyrene (PS) under a GFP filter shows an orange fluorescence, while high-density polyethylene (HDPE) fluoresces yellow. This enables preliminary identification of microplastics in food matrices, offers better resolution than light stereomicroscopy and is suitable for experimental applications. In one approach, polypropylene (PP) microplastics stained with Nile red were applied to raw chicken fillets. Although these particles were invisible, they were visible under a fluorescence stereomicroscope and remained attached to the filet even after gentle and vigorous washing.

Keywords: Microplastics, Fluorescence microscopy analysis, Microplastics in environment and food systems, Food safety

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THE ADVANTAGE OF LPM LAMPS EMITTING AT 185 nm - A SIMPLE SOLUTION TO ENHANCE THE EFFICIENCY OF PHOTOCHEMICAL WATER POST-TREATMENT PROCESS FOR ELIMINATING NON-BIODEGRADABLE ORGANIC POLLUTANTS

Tünde Alapi**, Anett Čović, Luca Farkas, Réka Bíró, Gyöngyi Orosz
Department of Molecular and Analytical Chemistry, University of Szeged, H-6720 Szeged, Dóm tér 7, Hungary,
**alapi@chem.u-szeged.hu*

The complete removal of persistent organic pollutants from water is one of the most challenging tasks in water purification, especially in drinking water treatment. The production of adequate quality drinking water is a universal problem today, partly due to the biologically active and persistent organic micropollutants, such as pesticides, drugs, and especially antibiotics, that cannot be removed by conventional water treatment processes. The tightening of legal regulations reflects the importance and topicality of the problem.
The Advanced Oxidation Processes (AOPs) as water treatment processes are based on radical generation and offers a solution to this problem. Some of the AOPs require UV radiation, such as UV/H_2O_2, UV/O_3, or UV/persulfate processes. Most often the low-pressure mercury vapor lamp (LPM) is used as light source, which emits 254 nm UV light having an excellent germicidal effect. The version of the LPM lamp with a high-purity quartz envelope is called an "ozone-generating lamp" and emits 185 nm VUV light in addition to 254 nm UV. Although this lamp is used on an industrial scale almost exclusively for producing high-purity water required for the electronics industry, its use in drinking water treatment would also be justified. The 185 nm photons are adequate to produce hydroxyl radicals from water and can enhance the efficiency of the UV/H_2O_2 and UV/persulfate processes. The higher price of the UV/VUV lamp compared to the UV LPM lamp (approximately 25%) can be compensated by the significantly lower dose of the oxidant, and permanent hydroxyl radical generation due to the VUV photolysis of water.
In this work, the efficiency of the UV/VUV photolysis, and the additive effect of the VUV light in the case of (V)UV/H_2O_2 and (V)UV/persulfate processes were investigated. Trimethoprim, a widely used and non-biodegradable antibiotic was used as the target substance. The effect of oxidant dose, and biologically treated domestic wastewater as a matrix on the transformation and mineralization efficiency were studied. Radical scavengers were used to investigate the role and contribution of various reactive species to the transformation. Special attention was paid to the effect of inorganic ions and formation of chlorinated organic products, and the change of ecotoxicity of the treated solution. Efficiency was compared in terms of electrical energy per order (E_{EO}) values.

Keywords: VUV photolysis, LED, Antibiotic, Advanced oxidation processes, Water treatment

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INACTIVE BIOMASS OF THE FUNGUS *Ganoderma applanatum* AND ITS BIOSORPTIVE POTENTIAL FOR REMOVING MALACHITE GREEN FROM WASTEWATER

***Natalija Velić*[1*], Marija Stjepanović[1], Jelena Vukoje[1], Janez Gorenšek[2], Sandra Budžaki[1], Marta Ostojčić[1]**
[1]*University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia*
**natalija.velic@ptfos.hr*
[2] *IAMB-Institute for Applied Mycology and Biotechnology, Vegova 26, Celje, Slovenia*

In this work, the biosorptive potential of the inactive biomass of the fungus *Ganoderma applanatum* for the removal of the cationic dye malachite green (MG) from model dye solutions and synthetic wastewater was investigated. The biosorption experiments were carried out in batch mode to investigate the influence of different factors on the biosorption process, namely the concentration of biosorbent (0.5 - 5 g/L), contact time (1 - 120 min), initial dye concentration (10 - 100 mg/L) and pH (4 - 10). An increase in biosorbent concentration resulted in an increase in the percentage of MG removal and a decrease in the amount of MG adsorbed per gram of biosorbent. The equilibrium state was reached within 120 minutes. Biosorption was very rapid in the first 30 minutes and then slowed down in the later stages until equilibrium was reached. The biosorption process was dependent on the MG concentration. pH values above 7 favored the biosorption of MG, as evidenced by a greater amount of adsorbed MG per unit mass of biosorbent and a higher percentage of MG removal. The biosorption process was better described by the Freudlich model and the biosorption kinetics by the pseudo-second-order model than by the Langmuir model and the pseudo-first-order model.

Keywords: Biosorption, Malachite Green, Ganoderma applanatum, Wastewater

EFFECT OF SODIUM CHLORIDE ON THE REMOVAL OF PHARMACEUTICALLY ACTIVE COMPOUNDS FROM WATER BY A REVERSE OSMOSIS MEMBRANE

***Jelena Šurlan*[1*], Zita Šereš[1], Nikola Maravić[1], Nataša Đurišić Mladenović[1], Igor Antić[1], Jelena Živančev[1], Carla Brazinha[2], João G. Crespo[2,3]**

[1] University of Novi Sad, Faculty of Technology, Bul. cara Lazara 1, 21000 Novi Sad, Serbia
[2]LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
[3]Instituto de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Av. da República, 2780-157 Oeiras, Portugal
**jelena.surlan@uns.ac.rs*

Pharmaceutically active compounds are often detected in the aquatic environment, including surface waters, ground waters and even drinking water, due to their insufficient removal by conventional wastewater treatments. Due to adverse effects of pharmaceutically active compounds on human health and the environment, additional methods for their removal from water sources are required. Membrane separation processes, including reverse osmosis, are considered to be one of the possible solutions for the removal of the corresponding contaminants from the aquatic environment. The aim of this study was to determine the efficiency of commercially available polyamide reverse osmosis membrane (SW30HR, FilmTec™) in the removal of four pharmaceutically active compounds (acetaminophen, carbamazepine, salbutamol and bezafibrate) from model water solution and evaluate the impact of sodium chloride addition on the removal of selected compounds. Experiments were conducted in METCell® dead-end unit from EVONIK (Germany) and the pressure of 30 bar set using a nitrogen gas cylinder. Rejections (%) from 86.28% to 96.53% were achieved with SW30HR membrane for all selected compounds without the addition of sodium chloride to the feed solution. However, addition of sodium chloride in the feed solution negatively impacted the removal of selected compounds, with the rejections from 64.35% to 80.58%. The highest impact of sodium chloride was observed for bezafibrate and salbutamol, with a total decrease in rejection of 23.13% and 21.94%, respectively. Addition of sodium chloride affected the diffusion of the selected compounds through the membrane by increasing the osmotic pressure and therefore, decreasing the removal of selected compounds.

Keywords: Reverse osmosis, Water treatment, Sodium chloride, Membrane separation processes

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PRELIMINARY PRODUCTION COST ESTIMATION FOR BIOSORBENTS DERIVED FROM PEACH STONES

Danijela Z. Stefanović**, Marija R. Miladinović, Biljana S. Đorđević, Milan D. Kostić, Olivera S. Stamenković
University of Niš, Faculty of Technology, Bulevar oslobođenja 124, 16000 Leskovac, Serbia,
**z.keys.fa@gmail.com*

The biosorption process has emerged as an environmentally friendly treatment technology for wastewater. Consequently, many biosorbents have been developed using waste biomass and successfully employed in the removal of various contaminants from wastewater. The fruit stones show significant potential as biosorbents, whether processed through mechanical or thermochemical treatments, thereby adding value to waste materials. The biosorption potential of peach stones has been investigated for the removal of various emerging contaminants from wastewater, including pharmaceuticals (carbamazepine, caffeine, and diclofenac), pesticides (carbofuran, 2,4D, and imidacloprid), synthetic dies (methylene blue) as well the hexavalent chromium. Estimating production costs for biosorbents is crucial for evaluating their economic performance alongside adsorption performance such as adsorption capacity and removal efficiency. This study presents an analysis of the preliminary production cost estimation of biosorbents derived from peach stones. Based on the production methods described in 6 different studies, the cost analysis considered the cost of raw material, transportation, drying, chemical activation, carbonization, and grinding. The cost estimation revealed that higher production costs are associated with processes involving chemical activation with phosphoric acid, especially if the impregnation ratio is higher. The cost of biosorbent production, depending on the method, ranges from €0.87/kg to €3.97/kg, which corresponds to reported values for thermochemically activated biosorbents. Despite the higher production cost of biosorbents, the lowest cost per gram of contaminant removed from wastewater was achieved for biosorbents used in the removal of carbamazepine (€0.011/g), caffeine (€0.015/g), 2,4-D (€0.018/g), and diclofenac (€0.021/g).

Keywords: Biosorbents, Peach stones, Cost estimation

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ADSORPTION EFFICIENCIES OF INDIAN NEEM LEAVES FOR REMOVAL OF CONGO-RED DYE FROM AQUEOUS SOLUTION FOR SUSTAINABLE ENVIRONMENT

***Radharani Das*[1*], *Ishita Sinha*[1,2], *Soumyajit Maity*[1] , *Subhojit Ash*[1]**
[1]*Department of Chemical Engg, Haldia Institute of Technology, Haldia, Haldia, West Bengal, India: 721657*
[2]*Linde India Ltd. Oxygen House, P-43, Taratala Road, Kolkata-700 088, West Bengal, India*
[*]*radha.das6@gmail.com; +91 9434453157*

Dyes and pigments are widely used in paper, plastic, leather, foodstuff, cosmetics, and specially in textile dyeing industries. Colored wastes generated from these industries contain many highly toxic complex dyes that are resistant to aerobic digestion and stable to photo-oxidation. Thus, removal of these complex materials from effluents is the most challenging problem for the environment. So, searching for new, low-cost technologies for removing these poisonous substances from industrial effluents has withdrawing continuous attention of the researchers using bio-adsorption process. In this paper, mature Neem leaves were used to develop a novel bio-adsorbent for removing Congo Red (CR) dye from synthetic solution. The developed adsorbent was analyzed using SEM, FTIR, and XRD studies. The sorption efficiency of Neem Leave powder (NLP) has been studied using the batch adsorption process. It was found that NLP in the form of fine powder with a size range of 250- 300 µm are very effective for removing the CR from its dilute solution. Experiments were carried out using solutions with various dye concentrations of 10 to 100 mg/l. The removal percentage of CR is determined by UV visible spectrophotometer at wavelength of 500 nm. Experimental results show that 90 – 96.56 % removal of CR may be achieved within 60-90 minutes using 2-8 g /l NLP. The observations also show that the maximum adsorption capability of NLP depends on various operating parameters like dye concentration, size of adsorbents and its activation process, pH of the solution and temperature. The applicability of the rearranged Langmuir and Freundlich model was also studied. The maximum adsorption capacity of the activated NLP for removal of CR was obtained as 86.96 mg/g at 308 K and pH 7.03. The correlation coefficient value (R^2) of rearranged Langmuir and Freundlich isotherm was obtained as 0.996 and 0.997respectively at 309 K. The thermodynamic studies show that the sorption process is exothermic and spontaneous. Kinetic studies at various temperature show the suitability of Pseudo Second order reaction for this adsorption process. The satisfactory values of regression coefficients (0.999) at different temperature, higher adsorption capacity and good fittings of adsorption isotherms indicate that activated NLP has excellent potential to use as an alternative low-cost adsorbent for the effective removal of Congo red (CR) dye from industrial effluents.

Keywords: *Neem Leaves; Congo Red; Adsorption Isotherms; Kinetics; SEM; FTIR*

ADSORPTIVE REMOVAL OF Cr(VI) FROM SYNTHETIC WASTES USING AGRICULTURAL WASTES: A GREEN APPROACH

***Radharani Das*[1*], G. Roymahapatra[2], Ishita Sinha[1,3] , Soumyajit Maity[1] , Subhojit Ash[1]**
[1]*Department of Chemical Engg, Haldia Institute of Technology, Haldia, West Bengal, India: 721657*
[2]*Department of Applied Sciences, Haldia Institute of Technology, Haldia West Bengal, India: 721657*
[3]*Linde India Ltd. Oxygen House, P-43, Taratala Road, Kolkata-700 088, West Bengal, India.*
[*]*radha.das6@gmail.com; +91 9434453157*

Effluents from various industries like electroplating, leather tanning, cement, petrochemicals, dyes, paper industries etc., contains significant amount of toxic hexavalent chromium, Cr(VI) with concentration of 10^{th} to 100^{th} ppm level. To avoid the health hazard from long term exposure of Cr(VI), there is a high demand of feasible cost-effective technologies which would eventually save aquatic as well as human lives from the carcinogenic effect of Cr(VI). As far as public health and the environment is concerned the presence of Chromium(VI) ions is considered to be highly hazardous since it is a cause of carcinoma and potentially mutagenic in nature. Thus, in order to maintain health and economic prosperity, the detection and removal of carcinogenic chromium(VI) from aqueous solutions were performed using activated sugarcane bagasse (SCB) and rice husk (RH) as an adsorbent. The experiments were performed under the different parametric conditions. It was found that the elimination of Chromium(VI) ions is dependent on adsorption time, nature and amount of adsorbent, concentration of solution, pH of the medium, and temperature. The determination of Chromium(VI) ions in the solution was performed by UV Spectro-Photometric analysis by growing a purple-violet complex with 1, 5-diphenyl carbazide in acidic solution at the wave length 540 nm. The results show that 88-99.45 % decrement of Chromium(VI) ions may be achieved from the solution of different concentration depending on the adsorbent amount, pH and temperature. Further, the applicability of rearranged Langmuir model and Freundlich Isotherm were also investigated using the experimental results. The optimum adsorption capacity obtained for RH and SCB were 58.83 mg/g and 38.75 mg/g respectively at the pH of 1.35. The reaction kinetics of adsorption for this sorption process has been performed using various kinetic models. The experimental observation signifies the cost-effectiveness of rice husk and sugarcane bagasse as a natural potential absorbent.
Thus, the experimental results show that the activated agricultural wastes may be used as a promising source of adsorbent for treating wastewater using adsorption process, a green and eco-friendly separation technique for the elimination of carcinogenic hexavalent Chromium(VI) ions from industrial wastes for environmental sustainability.

Keywords: Sugarcane bagasse, Rice Husk, Chromium(VI), Adsorption Isotherms, SEM

LIST OF PARTICIPANTS

Last name First name:		Affiliation, City, Country	E-mail:
1.	**Adamović** Aleksandra	University of Niš, Faculty of Technology	aaleksandra17@hotmail.com
2.	Alapi Tünde	University of Szeged, Department of Molecular and Analytical Chemistry, Hungary	alapi@chem.u-szeged.hu
3.	Al-Tayawi Aws N.	Doctoral School of Environmental Sciences, University of Szeged, Hungary	awsaltayawi@uomosul.edu.iq
4.	**Antić** Igor	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	antic@tf.uns.ac.rs
5.	Barbanera Marco	University of Tuscia, Department of Economics, Engineering, Society and Business Organization	m.barbanera@unitus.it
6.	Beszédes Sándor	University of Szeged, Hungary	beszedes@mk.u-szeged.hu
7.	**Bogunović** Minja	Faculty of Sciences, University of Novi Sad, Serbia	minja.bogunovic@dh.uns.ac.rs
8.	Budžaki Sandra	Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Croatia	sandra.budzaki@ptfos.hr
9.	**Buljovčić** Maja	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	maja.buljovcic@uns.ac.rs
10.	Crespo Joao	NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal	jgc@fct.unl.pt
11.	**Čojbašić** Sanja	Faculty of Technical sciences, University of Novi Sad, Serbia	sanjaradovic@uns.ac.rs
12.	**Čović** Anet	Department of Molecular and Analytical Chemistry, University of Szeged, Hungary	covicanett@chem.u-szeged.hu
13.	Das Radharani	Haldia Institute of Technology, India	radha.das6@gmail.com
14.	Das Samanta Lipika	Haldia Institute of Technology, India	lipikadas24@gmail.com
15.	Dragosavac Marijana	Loughborough Univeristy, UK	m.dragosavac@lboro.ac.uk
16.	**Đurišić–Mladenović** Nataša	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	natasadjm@tf.uns.ac.rs
17.	Gominho Jorge	Instituto Superior de Agronomia, Centro de Estudos Florestais, Portugal	jgominho@isa.ulisboa.pt
18.	Grba Nenad	University of Novi Sad, Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences,	nenad.grba@dh.uns.ac.rs

		Serbia	
19.	Hodúr Cecilia	University of Szeged, Hungary	hodur@mk.u-szeged-hu
20.	**Ivančev Tumbas** Ivana	University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Serbia	ivana.ivancev-tumbas@dh.uns.ac.rs
21.	Ivanovska Aleksandra	University of Belgrade, Innovation Center of the Faculty of Technology and Metallurgy, Serbia	aivanovska@tmf.bg.ac.rs
22.	Jákói Zoltán	University of Szeged, Faculty of Engineering, Department of Biosystems Engineering, Hungary	jakoiz@mk.u-szeged.hu
23.	Kerkez Djurdja	Faculty of Sciences, University of Novi Sad, Serbia	djurdja.kerkez@dh.uns.ac.rs
24.	Kertesz Szabocs	Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Hungary	kertesz@mk.u-szeged.hu
25.	Kiss Ferenc	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	fkiss@uns.ac.rs
26.	László Zsuzsanna	University of Szeged, Department of Molecular and Analytical Chemistry, Hungary	zsizsu@mk.u-szeged.hu
27.	**Lončarević** Ivana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	ivana.loncarevic@uns.ac.rs
28.	**Lukić** Dragana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	dkukic@uns.ac.rs
29.	**Maletić** Snežana	Faculty of Sciences, University of Novi Sad, Serbia	snezana.maletic@dh.uns.ac.rs
30.	**Maravić** Nikola	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	maravic@uns.ac.rs
31.	**Miladinović** Marija	University of Niš, Faculty of Technology, Serbia	marijamiladi@gmail.com
32.	**Molnar Jazić** Jelena	University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection , Serbia	jelena.molnar@dh.uns.ac.rs
33.	Nath Arijit	Department of Food Process Engineering, Hungarian University of Agriculture and Life Sciences, Hungary	arijit0410@gmail.com
34.	Nemestothy Nandor	University of Pannonia Research Group on Bioengineering, Membrane Technology and Energetics, Hungary	nandor.nemestothy@mk.uni-pannon.hu
35.	**Nikić** Jasmina	University of Novi Sad, Faculty of Sciences, Serbia	jasmina.nikic@dh.uns.ac.rs

36.	**Nikolić** Ivana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	ivananikolic@uns.ac.rs
37.	**Nikolić** Milan	Faculty of Agronomy in Čačak, University of Kragujevac, Serbia	milanik@kg.ac.rs
38.	Pajin Biljana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	biljana.pajin@uns.ac.rs
39.	**Panić** Sanja	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	sanjar@tf.uns.ac.rs
40.	Pereira Vanessa	iBET, Instituto de Biologia Experimental e Tecnológica, Portugal	vanessap@ibet.pt
41.	**Perović** Lidija	University of Novi Sad, Institute of Food Technology Novi Sad, Serbia	lidija.perovic@fins.uns.ac.rs
42.	**Petronijević** Mirjana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	mirjana.petronijevic@uns.ac.rs
43.	**Petrović** Jovana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	jovana.petrovic@uns.ac.rs
44.	**Petrović** Sanja	University of Niš, Faculty of Technology, Serbia	milenkovic_sanja@yahoo.com
45.	**Rakić** Dušan	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	dusan.rakic.1995@gmail.com
46.	**Savić** Saša	University of Niš, Faculty of Technology, Serbia	sasa.savic@tf.ni.ac.rs
47.	Smole Možina Sonja	Biotechnical Faculty, Department of Food Science and Technology, University of Ljubljana, Ljubljana, Slovenia	sonja.smole@bf.uni-lj.si
48.	Soares Olívia Salomé	Faculty of Engineering, University of Porto, Portugal	salome.soares@fe.up.pt
49.	**Stefanović** Danijela	University of Niš, Faculty of Technology, Serbia	z.keys.fa@gmail.com
50.	**Šćiban** Marina	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	msciban@uns.ac.rs
51.	Šereš Zita	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	zita.seres@uns.ac.rs
52.	**Šobić** Marija	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	sobicmarija@gmail.com
53.	Šoronja – **Simović** Dragana	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	dragana.soronja@uns.ac.rs
54.	Šurlan Jelena	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	jelena.surlan@uns.ac.rs
55.	**Vasić** Vesna	University of Novi Sad, Faculty of Technology Novi Sad, Serbia	vesna.vasic@uns.ac.rs
56.	Velickova Nikova Elena	Faculty of Technology and Metallurgy, Ss Cyril and Methodius University in Skopje	velickova@tmf.ukim.edu.mk
57.	**Velić** Natalija	University of Osijek, Faculty of	natalija.velic@ptfos.hr

		Food Technology Osijek, Croatia	
58.	Veréb Gábor	Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Hungary	verebg@mk.u-szeged.hu
59.	**Vujić** Maja	University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Serbia	maja.loncarski@dh.uns.ac.rs

AUTHORS' INDEX

About TwiNSol-CECs Project

TwiNSol-CECs will generate the collaborative environment required for University of Novi Sad, Faculty of Technology Novi Sad (TFNS), Serbia, to increase and implement its research in the field of CONTAMINANTS OF EMERGING CONCERN (CECs). This will be accomplished by twinning under Horizon Europe programme with two EU research intensive institutions with strong expertise in the field:

- Spanish National Research Council, Institute of Environmental Assessment and Water Research (CSIC), Barcelona, Spain, and
- NOVA University Lisbon, NOVA School of Science and Technology (UNL), Lisbon, Portugal,

which eminent researchers will help TFNS to unlock the scientific potential through intensive networking, transfer of knowledge and technical expertise.

Surveillance of CECs and improvement of the removal technologies have important role in protection of humans and the environmental resources. Such efforts are in compliance with the European Green Deal (EGD) commitment for transition of EU to zero-pollution, toxic free environment. They are also in line with the 2030 Agenda for Sustainable Development. Preserving the quality of water, air, and soil, protecting the drinking water sources, and promotion of the water protection, and pollution reduction from the source to tap, are among the priority actions of EU Strategy for the Danube Region.

TFNS recognized the Twinning Western Balkans call under HORIZON EUROPE progamme of European Union as an opportunity to reinforce own capacities already proven in innovative CECs analysis and removal methodologies and to strengthen its position in the European Resaerch Area. The project answered the call requirements, and it was evaluated with 14.5 out of 15. It started on August 01, 2022 and will last 3 years. The project maximum grant is 1 432 937.50 Euros. The full project name is “TWINNING FOR ENHANCING THE SCIENTIFIC EXCELLENCE OF FACULTY OF TECHNOLOGY NOVI SAD FOR INNOVATIVE SOLUTIONS TO PROTECT ENVIRONMENTAL RESOURCES FROM CONTAMINANTS OF EMERGING CONCERN”.

The project represents a coherent set of knowledge, skills, experience, and awareness raising activities, dissemination, communication, networking, coordination, etc. for successful achieving of the project objectives.

More about the project with the latest news on project activities and events may be found at the project web site www.twinsol-cecs.com.